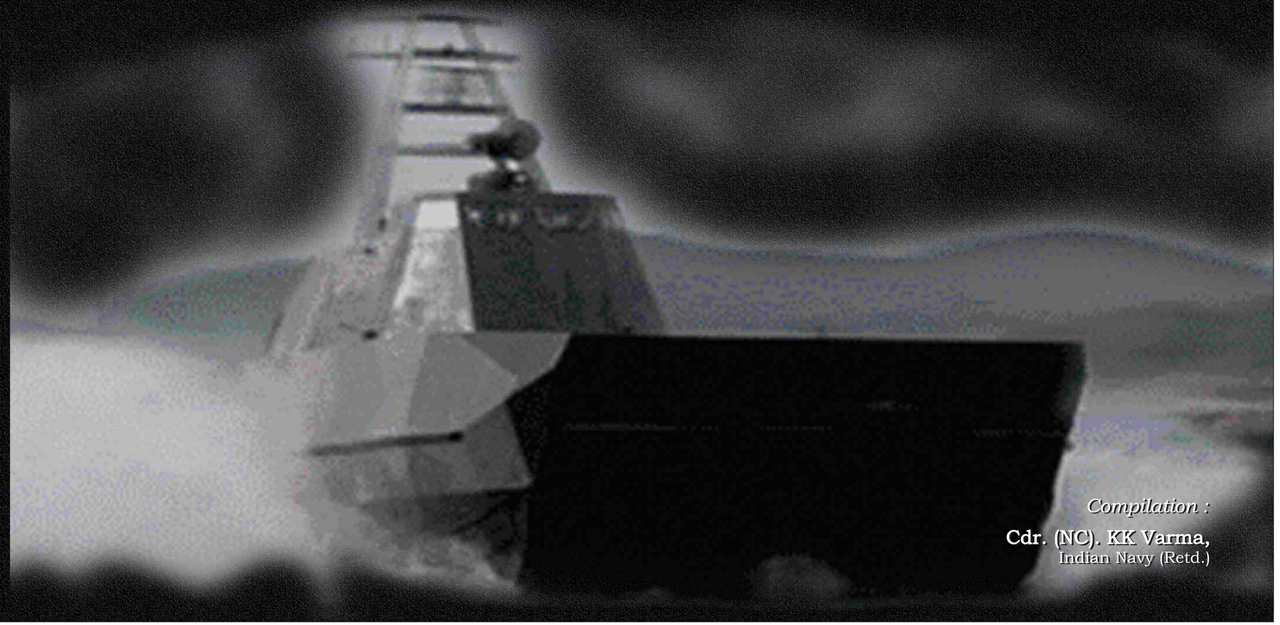
NAVAL CONSTRUCTION IN INDIA

50 Years of The Corps of Naval Constructors,
Indian Navy : (1956 2006)



Compilation :
Cdr. (NC). KK Varma,
Indian Navy (Retd.)

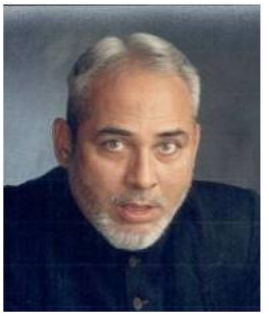
What is fifty years in the life of a country? Not much, really. Especially, if the country has thousands of years of rich history … like India! And yet, it is amazing, how much the country can 'achieve' in fifty years… Naval Construction in India is one such success story!

India has had maritime traditions since antiquity. And the ships designed & built by the Indian Master Tradesmen, have forever been highly acclaimed the world over, for their all-round quality. Quite a few Indian 'states' have had their own navies too who fought many a famous wars-at-sea. However, the 'construction' of the ships used by *these* navies, is not being covered under the expression "Naval Construction"; for two reasons. One, there was hardly any technical difference between the warships & the commercial ships of that era. Secondly, these navies had a 'local', rather than 'national' status. Before the 'birth' of the Royal Indian Navy, India did not have the 'marine' arm of its national fighting force. In a way, therefore, the story of Naval Construction in India has just begun!

The present book attempts to unveil this fascinating story in a simple & interesting narrative… It starts with defining 'Naval Architecture', bringing out the 'art' & the 'science' parts of it, digging briefly into its history in the Shipwright trade, highlighting the fact that the 'Indian part' of this history is still largely un-discovered, 'hidden' under the British suppression over the last hundred years of its rule! It then introduces the Naval Constructors, the designers & builders of warships, bringing out the difference between Naval Architects & Naval Constructors, in the process celebrating fifty years of formation of the Corps of Constructors in the Indian Navy.

The period of fifty years, from 1956 when the Corps was formed to 2006, has been presented as five decades of progressive growth, naming the periods from 'Conception', to 'Consolidation', 'Transition', 'Evolution', & 'Recognition'. It has been the author's intention to cover as many aspects of the 'collective contribution' of the Corps as possible, with no particular reference to the technical aspects of the profession, other than to amplify the involvement or the achievements of certain individuals. The 'old soldiers' of the Corps will find an acknowledgement of their contributions, big or small, while those who are 'new' into the family, will discover with-in the pages of this book, the raison d'etre for pride in the Corps.

Unless the members of the Corps are vividly aware of its chequered history, rich heritage & ethos, they cannot possibly be expected to inculcate a sense of pride in it. They have to have a raison d'etre… And that is what "Naval Construction in India" aspires to provide!



Kuldeep Kumar Varma, popularly known as "KK", retired as Commander, in 1989, after serving the Indian Navy for over 20 years. After completing his graduation in Naval Architecture with First-Class (Honours), from IIT Kharagpur, then a five & a half year course, he joined the Indian Navy as the 22nd uniformed officer in the Corps of Constructors, (25th, including the three civilian Naval Architects). The Corps now has over 350 officers, nearly half of whom have been his 'student' at some stage of their careers, or the other!

On completion of his PG Specialization from UK, as Lieutenant, he was posted to the then Base Repair Organisation, (BRO), Visakhapatnam, in the rank of Acting Lt. Cdr. As the BRO grew into the Dockyard, ND(V), he was instrumental in setting-up & operating the Fabrication &, the Outfitting & Dry-docks departments, including the South Dry-dock, & was the Project-Coordinator for the 'covered' North Dry-dock. For some time he also looked after the newly established Constructors' Training Office, in addition to the other two portfolios.

Cdr. Varma served the Directorate of Naval Construction twice, once as Staff Officer & the second time as Deputy Director. It was on account of his initiative in his second tenure as DDNC, that the name of the Directorate was changed from DNC to DNA, in 1985.

Cdr. Varma held the prestigious appointment of Officer-in-Charge, Naval Construction Wing, (NCW), at IIT Delhi for three years, from 1986 to 1989, during which the NCW got a complete face-lift, professionally, as well as, physically. He was the 'founder Secretary' of the "Delhi Chapter" of Institution of Naval Architects & the originator of the annual Commodore Garg Memorial Lecture programme.

His last appointment in the Navy was in Project Seabird, where he made major contribution in the evolution of the various repair/construction facilities/layouts, including the selection of the synchro-lift facility. After retirement from the Navy, he served the Ministry of Shipping in the National Ship Design & Research Centre, (NSDRC), Visakhapatnam, for ten years. He is presently a free-lance Consultant & Honorary Faculty in the Department of Naval Architecture & Marine Engineering, at Andhra University, Visakhapatnam.

Cdr. Varma is not a professional 'writer'; he considers his creative talent as God's gift & a Constructor's trademark! Main amongst his 'creations', other than the "Corps Song", are the documentary films that he wrote & directed for the Corps of Constructors, as well as, for NSDRC, & the logo's that he designed for NCW & NSDRC.

ACKNOWLEDGEMENT

Ships have always played an important role in shaping human destiny whether they ply the water for peaceful or for martial ends. Ships and their movement on the vast oceans of the planet etched the fate of our forebears and to this day, they define the measure of our national aspirations. In pursuit of trade, exploration, and defense, ships and the sea-lanes of communications are vital to national prosperity and survival.

This book attempts to chronicle the history of the 'ship' from its birth in antiquity to modern times, and in the process celebrates the history of the 'Indian Corp of Naval Constructors' on its 'Golden Anniversary.' Also, the book endeavors to reflect on the evolution of the career of the Indian Naval Constructors who are essentially 'naval architects' responsible for constructing and designing warships that meet the highest standards of seaworthiness in pursuit of national safety of the Indian Peninsula.

I find this book reflects my career: when I started in the 1960's as a naval architect trained as a craftsman, and given the opportunity to present my work in a form that exhibited my creativity and aesthetic values in design; and, when I left the Corps towards the end of 1980's, the work had evolved to being more of a technocrat, compiling electronic data of available designs and modifying the drawings to meet the requirements of the task on hand.

I am indebted to the Corps, in general, & specifically to Rear Admiral MK Badhwar, the present Director General of Naval Designs; & Commodore V Sequeira, the erstwhile Director of Naval Architecture, for having the faith and respect in my professional and creative writing abilities to entrust me with this exalted privilege of writing a book of such breadth and scope honoring the 50th year of the Indian Naval Corps of Constructors. The golden years are truly a cause for celebration in life whether it is a person or an institution. It brings with it bittersweet memories of days gone by, the trial and tribulations along with the joys and happiness of the times, and the pride in serving the Indian Corps of Naval Constructors.

I have benefited from the advice of all the senior Constructor officers, in particular Cdr. DCJ Deans (Retired), Capt. KK Lohana (Retired); & Rear Admiral RS Chaudhry, (Retired), who provided me invaluable guidance in compiling this book. I would like to acknowledge my Naval, as well as 'non-Naval' friends, colleagues, and students, who thoughtfully answered my emails, questions, personal interviews, and reviewed the manuscript for editing. I must specially thank the Naval Construction Wing staff, under Cdr. VK Satyam, for not only providing me with all the facilities at their disposal, but also for meeting all my 'demands' with pleasant faces. And my very special thanks are due to Cdr Atul Killedar & his team, who literally had to slog in converting my colorless write-up into this colorful coffee table book.

Last but not the least, I would like to thank my wife for being considerate as even after retirement I spent many hours on the computer and had to be away for many days from home working on this publication. And of-course, I would be amiss if I did not thank my children for the joy and happiness they bring in my retired life.

… **KK Varma**

DEDICATION

I dedicate this work

To : **GOD**.

For giving me life,

With the **divine gift**,

That keeps me inspired,

Across the vast oceans…..

… Kuldeep.

Introduction

"*Apsu Jyotir-pratishthitam…*" declare the Vedas, (*Taittiriya Upanishad*); meaning, "In the Water, is enshrined, the flame (of light)." Sanskrit word *Jyoti* has different meanings in different context, e.g. the light of life; the light of wisdom; the light of prosperity, etc. In fact, there are 'many lights' according to the Vedic Seers, & among those, 'the light of wisdom' is supposed to travel the farthest, ("*Dooram Gamam Jyotisham Jyotirekam…*"). Modern Science has already acknowledged that 'the light of life', did indeed, get kindled in water… Archaeological excavations corroborate that 'wisdom' & 'prosperity' grew 'out of' water too, at least in case of the human beings; for, all the prehistoric civilizations, without exception, developed along the waterfronts only. The earliest man 'opened his eyes', surrounded by water, in a way… watching things 'floating', being perhaps, his only recreation! Floating wooden logs in flowing waters, therefore, must have been his first 'mode of transportation'… as also, the modest beginning of *Naval Architecture*, 'the Art, and the Science of the design & construction of water-borne vessels & structures'.

A floating vessel of some utility can be built with only the most elementary thought for design, such as a few fallen logs collected at the edge of a stream and lashed together into a crude raft. In course of time, shaped wooden planks must have replaced irregular floating logs. It is such crude beginnings, that over the many centuries of intuition and trial-and-error, have grown today into an array of complicated and highly sophisticated structures. There can be little doubt, however that the first 'ship' must have

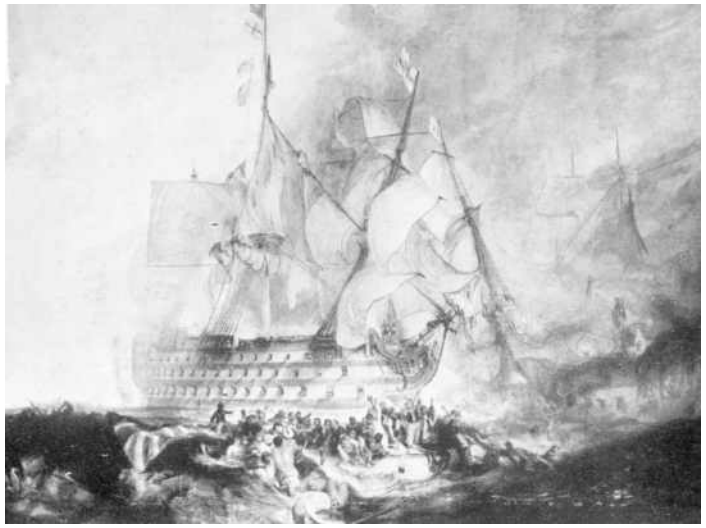
Caricature by Cdr Amitabh Dube, depicting the Naval Architect walking out of the "churning ocean" with the ship in one hand and the design documents in the other. The conch is the symbol of creativity and the lotus that of aesthetics. The Naval Architect is carrying the gear and the spanner; and the spark of wisdom !

been nothing but the result of man's indomitable spirit of enquiry & adventure. Naval Architecture therefore may well contend to hold the distinction of the 'Oldest Skill', if not the 'Oldest Profession!' It was only later that the adventure gave way to the 'need'; & the human nature being what it has always been, the 'need' ended up in 'greed'… There were wars & the Navies were born… And with them, the Naval Constructors… Navy's Naval Architects!

<u>*Craft Vs. Trade*</u> **:** Naval Architecture as a 'profession', has traditionally been more of a 'Craft', than a 'Trade'. The essential difference between the two, which is not always obvious, being that the craftsman is able to exercise control of the design and presentation of the work, whereas the tradesman may not.

At the turn of the 20th century the shipbuilding industry saw the development of 'design teams', which replaced the earlier tradition of the brilliant, 'single designer' taking decisions… There were now 'specialists' who oversaw different aspects of each vessel! The technical development continued, through the First World War, the cyclical depressions of the 1920's and 30's, and the Second World War, with the introduction of turbine and diesel propulsion, supercharging of engines, turbo-electric propulsion and much higher engine speeds; longitudinal framing replacing the traditional transverse frames; etc.

Towards the beginning of the Second World War, *electric arc welding* began to be introduced into the yards, albeit on a limited scale then. The 'good old' riveted construction was essentially a piece-by-piece assembly where nearly every component was fitted to the next on the building berth to ensure accurate lining up of the ship's structure. Welding allowed components to be fitted together in sub-assemblies on a flat surface, where down-hand welding could be employed, thus making for easier, and cheaper, construction. It also allowed girders and stiffeners to be used in a manner that produced stronger and lighter construction. Whereas riveted angle bar stiffeners were fixed by the flat part of the angle, welded stiffeners were reversed and welded by the 'toe', so that most of the metal of the stiffener was away from the plate to be stiffened, resulting in a much stronger structure, so that a smaller size of angle bar could be fitted, thus saving weight and cost. Each sub-assembly could be turned



'Craft' and 'trade', both are components of warship in making her 'to float','to move' and 'to fight'

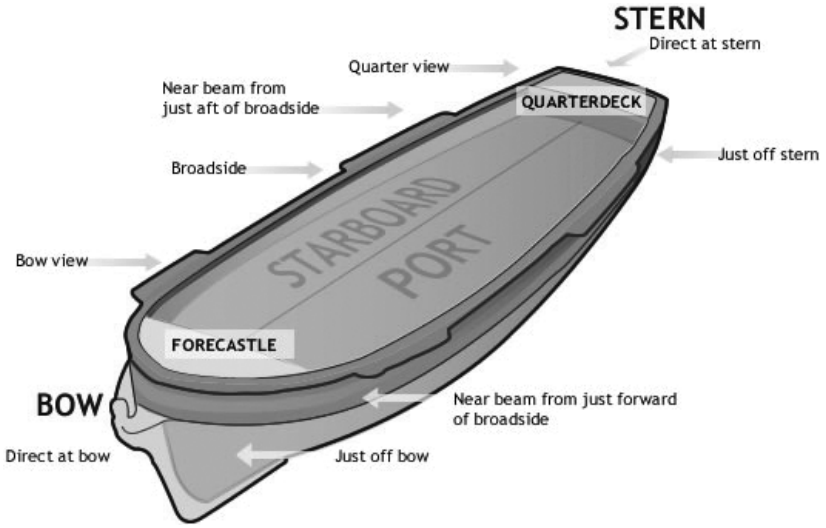
around to facilitate easier welding and attachment to other sub-assemblies.

The disadvantage with the new technique, that the welding causes shrinkage and some distortion of the metal, unlike the fastening of riveted joints, meant that allowance for distortion had to be made in the design, planning, and material cutting stages. Before the advent of welding and prefabrication there was not much that the Designer had to know about the yard facilities, but now the 'knowledge' had to be related to the requirements of 'erection'. The technique of 'pre-outfitting' increased the work of the drawing offices, as also of the planning, production, and purchasing departments, in terms of parts lists and building schedules. The sheer volume of necessary drawings was now beyond the old-style tradition of a single designer.

With the introduction of computers in the early 1980s, Naval Architects became more of technicians, involved with compiling electronic data. Drawings and details could be selected from files, and modified by others, so that the final drawing need no longer be the work of a single person. The hand-drawn plan with its individual printing style and other idiosyncrasies had disappeared altogether, and with them, the essential elements of craftsmanship.

Thus, the Naval Architect today, is more of a tradesman, than a craftsman… & shipbuilding is a 'trade' rather than 'craft'! The old axiom, "Each ship has to be tailor-made", has given way to the hard fact of reality; like any other 'product', the ship is also a 'product'. The International Standards Organization (ISO) is already in the process of giving final touches to "STEP", the 'Standard for Exchange of Product Model Data' in respect of commercial ships! Warships may also fall in "STEP"… It is just a question of time.

The 'Shipwright Trade' **:** Generally the words *vessel, ship, boat, watercraft*, etc. are used fairly interchangeably; however, each one has a specific technical definition. In modern nautical terms, a *vessel* is any object or craft that can be used for transportation upon the water. By this



The left side of ship moving ahead is called the "Port" and the right-side, the "Starboard"…

definition, both a log raft and a super tanker are vessels! The word *boat* generally refers to small craft. As a rule of thumb, a boat is any vessel that can be lifted out of the water and placed aboard a ship. These days, the word *ship* is used to describe any large vessel. But the original definition of ship has nothing to do with the big, power-driven vessels of today. The word *ship* was originally used to describe a fully rigged sailing vessel, made of wood & propelled by the oars!

People engaged in the construction of wooden vessels in UK, who oversaw the building of ships, the way a master craftsman would oversee the building of furniture, came to be known as the 'shipwrights'. The correct spelling for someone who writes plays is *playwright*—that's not 'write' as in writer, but *wright,* meaning 'a builder' — not just a worker of words, but a '*constructor*' who must know all his materials and understand how they can fit together in an original design.

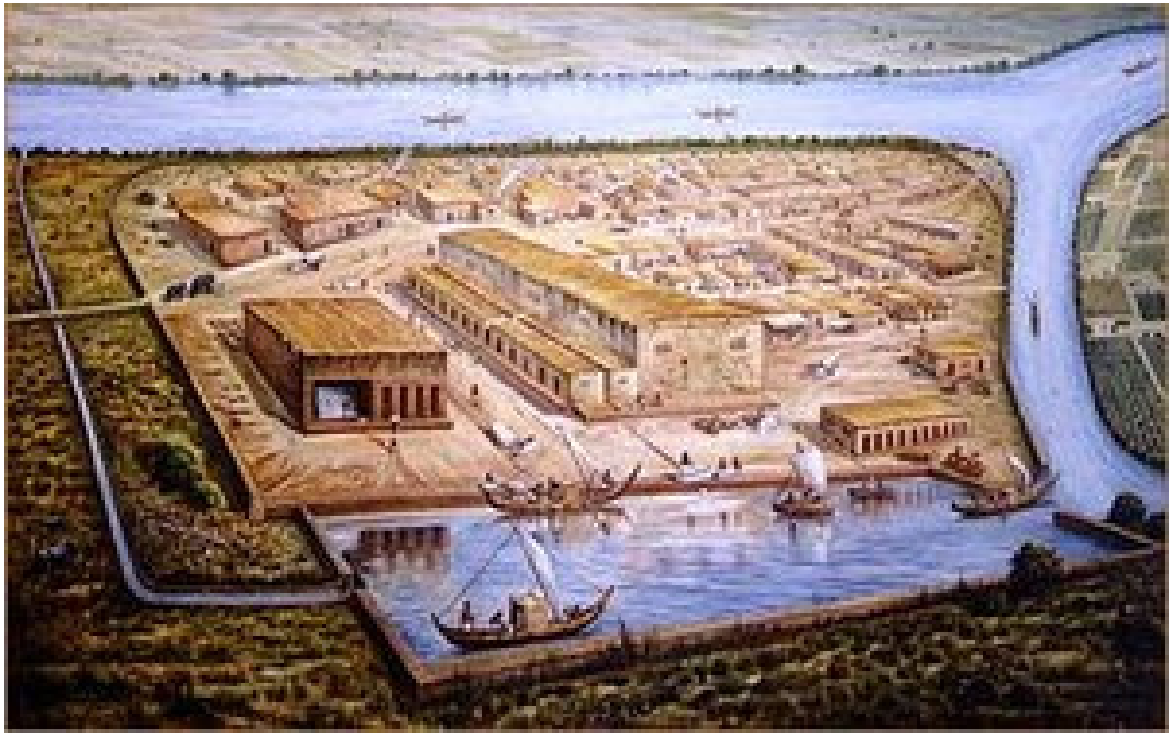
A typical Liberty ship. 100s of Liberty ships were virtually mass produced by the American shipbuilders during the II world war.

The skills of the shipwrights in pre-industrial Europe required little theoretical knowledge—just the ability to take measurements and perhaps perform rudimentary mathematical tasks. It was a conservative tradition that copied the models of successful vessels and risked little in experiment. A successful vessel could be reproduced using templates and rib-bands or by reproducing frames through the use of whole molding. The master shipwright often filled the roles of owner, foreman, lumberjack, designer, bookkeeper, teacher, salesman, and, perhaps, ship owner. He had the skills to carry through the entire production process from stump to ship. The so-called 'shipyard' stood at the center of a work hierarchy, where the master shipwright labored alongside his men and had close personal contact with his workers. Instead of shipyard labor being divided into trades, it was separated more by skill level, with master craftsmen at the top; journeymen in the middle; and laborers, apprentices, and boys at the bottom. The art of shipbuilding was handed down from master to apprentice, or father to son.

Rather than rising above their station, the shipwrights maintained a certain social status that they passed along to generations of male descendants. The extended family network formed a cornerstone of the culture and trade of shipbuilding. At least as far back as the thirteenth century, documents indicate a strong family orientation toward the craft of shipbuilding; it was not uncommon in the shipyards to find dynasties where several generations of one family worked side by side as shipwrights.

'Apprenticeship' continued to be the method of training young shipbuilders prior to Industrial Revolution. The apprenticeship system represented a holistic approach to learning the 'craft' where the master shipwright trained the apprentice in all of the various aspects of wooden shipbuilding, such as hull construction, joinery, caulking, scraping and painting, perhaps even timber selection and rigging. The learning process was a hands-on approach based on practical experience and the implements of the trade. It encouraged strong bonds between the apprentices, master shipwrights, and other shipyard workers : the esprit de corps!

Apart from the social and cultural forces, craft knowledge was also passed through, by technological factors. Ships usually sailed from one seaport to another. Shipbuilders needed only to stroll to the wharves near their shipyards to observe the latest in designs from foreign yards. The results of new design and construction methods used to build merchant, naval, and pleasure craft would rarely remain secret for long. However, it was not until the middle of the 18th century that the slow road toward the 'professionalizatio n' in shipbuilding



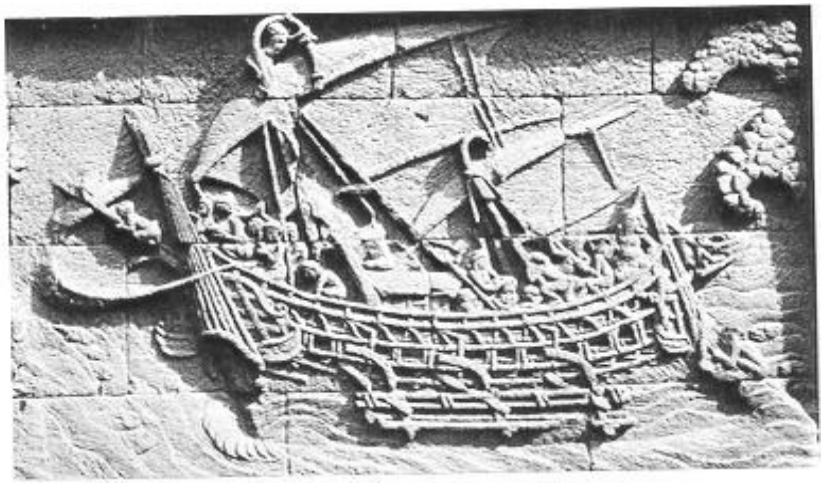
Artist's impression of Lothal harbour and the dry dock

began in Europe. Ironically, by about this time, the art of shipbuilding in India, was 'dead'!

Early Shipbuilding in India

There can be little doubt that shipbuilding in India must have followed a history similar to the shipwright culture in Europe; it was perhaps much older! Unfortunately no definite records are available of the period beyond about 5000 years BC, but the excavations at Lothal, a major port city of the erstwhile Harrappan civilization of India, said to be covering a region about half the size of Europe, & extending for a period of over 1,000 years, from around 3,000 BC to 1500 BC, have un-earthed a 'dry dock' used for repairing as well as building ships. So far, it remains the earliest known dry-dock in the world, rendering India therefore, as one of the earliest "Shipbuilding Nation", if not 'the First'! Indeed, there was a time, not very long ago, and well recorded in History, when ships designed & built by the Indian master craftsmen, reigned supreme on both sides of the Indian Ocean.

Although several nations that traded in the Indian Ocean had merchant ships, India seems to have been the first country of the Indian Ocean to possess the battle-fleets. The term *naval warfare*, also appears to be mentioned as a distinct entity, in Vedic, Epic and the Dharma-Sastra literature, suggesting that there was a continuous Naval tradition in India, from the earliest times. The word *Navy*, incidentally, comes from the Latin *navis*, meaning 'ship'. Navis is related to Greek *naus*, also meaning 'ship', which gives English such words as *nautical*, *nausea* and *naut*, (words such as *argonaut*, *astronaut*, etc.). *Navigate* also comes from Latin *navigare*, ('navis' + 'agere', meaning 'to drive, or, guide'). All of these words are ultimately derivations of the Sanskrit, root *nau*, (or, 'nav'), which stands for 'boat'. Sanskrit word for 'navigation' is *Navgatih*, meaning, 'to sail'. It is only now being slowly realized that the Indians were well ahead of their time in the field of 'navigation' too. In fact, the 'success' of Vasco-da-Gama 'discovering' India, is also attributed to an Indian naval pilot! After rounding the Cape of Good Hope, Vasco-da-Gama had apparently gone up the east coast of Africa where he had to hire an Indian Gujarati pilot who navigated him across the Arabian Sea to make landfall on the western Indian coast at Calicut.



A carving depicting ancient Indian ship

Some scholars credit Chandragupta Maurya, the founder of Maurya dynasty in the year 300 BC, of creating for the first time, the Admiralty, as a department of the State. This is on account of the term *Navadhyaksha*, the 'Superintendent of the Boats', quoted in the famous book on Economics, "Artha-Shastra", written by Kautilya, the equally famous Prime Minister of Chandragupta. It is however possible that by *Navadhyaksha* was perhaps only meant an 'in-charge' of the boats (or, marine vehicles) of a particular coastal state, and not the Admiral of the 'national' fleet as such… just as the *Ashwadhyaksha* was that of the 'horses', pertaining to respective states that together, formed the entire kingdom. According to the written accounts there was apparently a class of 'ship-builders' among the artisans, who were salaried public servants and not permitted to work for any private persons. The ships that they built, though in royal shipyards, were however, let out on hire; both, to those who undertook voyages, as also to professional merchants. The intercourse as envisaged in the literature therefore, shows relations to be more commercial than political in character.

It is the 12th century AD Sanskrit compilation, "Yukti-Kalpa-Taru", (*The Wishing-tree of Artifice*), composed by the king Bhoja Narapati of Dhar, that provides a comprehensive overview of the art of shipbuilding in ancient India. It gives a very scientific classification of 'wood', for instance, mentioning the quality of timber that is required for construction of seagoing ships that would resist the action of waves, currents, marine biofouling, etc. For, ships used to be made of wood at that time, and, in fact, continued to remain 'wooden' till the early 19th century, when 'steel' replaced wood for good! Unfortunately this technology-revolution took place at a time when the Indian shipbuilding was already being throttled by the British. Indian iron & steel technology of the period, otherwise, was as advanced, if not more, than any other in the world! In fact, the 'rust-free steel' was an Indian invention, and remained an Indian skill for centuries. Delhi's famous iron pillar, dated 402 CE, is considered a metallurgical marvel even till today. Also, the famous Damascus steel swords, now displayed in museums across Europe, were made from Indian steel imported by Europeans.

The Indian textiles, too, have been legendary since ancient times. Before this industry came under the British 'squeeze', starting from the 18th century, the textile technology was successfully used in designing & manufacturing the most colourful & efficient 'sails' for the

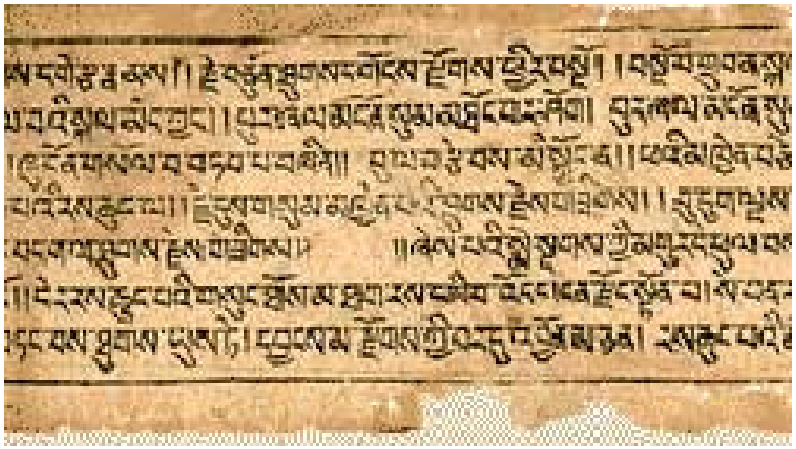
Statue of Seth Walchand Hirachand, the founder -owner of Scindia Shipyard, Visakhapatnam and the pioneer of commercial shipbuilding in India

Indian designed & built ships, for; they were all ‘sailing ships’ till that time.

The transition from sail to ‘steam’ & from ‘steam’ to ‘power’ also came, again, at the ‘wrong’ time for India! Since the British shipbuilders had refused to transfer this technology to the Indians and since industrialization in India had lagged way behind the European nations, the shipbuilding industry in India was doomed to virtual extinction. Though the Bombay Dockyard had succeeded in building its first steamship, *Hugh Lindsay*, as early as in 1830, it had failed to sustain the effort of updating the technology of building ironclads and therefore, got subsequently relegated to the status of just a maintenance and repair yard.

While laying the 'foundation stone' of the Scindia Shipyard, (later renamed 'Hindustan Shipyard Limited’), at Visakhapatnam, India, on 21 June 1941, Babu Rajendra Prasad, who later took over as the first President of India, summarized the ‘history’ in his brief speech : "… Indian shipbuilding was thus able to hold its own till about 1840. A revolution in the technique of ship construction & ship propulsion took place on account of the use of steam power & the use of iron plates in place of timber. Independent countries introduced the necessary changes & were able to build up their own marine. But India had to go to the wall, in the interest of British shipping. Taylor says that, "*The arrival in the port of London, of Indian produce, in India built ships, created a sensation among the monopolists which could not be exceeded if a hostile fleet had appeared in the Thames. Shipbuilders of the port of London took the lead in raising the cry of alarm. They declared that their business was in danger & the families of all ship-wrights in England were certain to be reduced to starvation*". A Committee was appointed by the Court of Directors to investigate the petition of the British shipbuilders. The evidence collected by this Committee shows that India ships were better than any ships built in England, lasted very much longer, were cheaper in construction & required less repair. The result was a recommendation that no India built ship was to be accepted on the English register & this is how shipbuilding in India came to an end. "

In *Yukti-Kalpa-Taru*, the ‘sail’ is addressed as the *Vata*

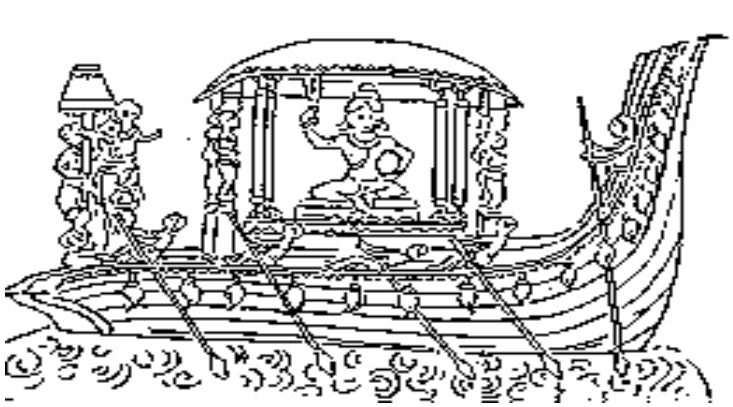


A leaf from *Yukti-Kalpa-Taru*

Vastra, literally meaning the 'wind-cloth'. The hull is termed *Sthula-Bhaga* i.e. an 'expanded area'. The rudder is called *Keni-Pata*, or *Karna*, meaning ‘ear’, because it used to be a hollow curved blade, as is found today in exhaust fans, (*Pata* means blade). The ship's keel was called *Nava-Tala*, which means 'bottom of a ship'. The mast was known as *Kupadanda*, where *danda* stands for a ‘pole’. The ship's anchor was known as *Nava-Bandhan-Kilaha*, which literally means 'A Nail to tie up a ship'. Even a sextant was used for navigation and was called *Vruttashanga-Bhaga*. What is more surprising is that even a contrived mariner's compass, called *Matsya Yantra*, was used by Indian navigators; it comprised of a magnetic fish that floated in a vessel of oil and pointed to the North. And it is for the reason of its magnetic properties that though *Yukti-Kalpa-Taru* recommends various metals to be used onboard ships for decorations, e.g. Gold, silver, copper, and compounds of all three; the use of *iron* is not advocated anywhere. Elaborate directions have been given, for decorating and furnishing the ships with a view to making them comfortable for passengers. There are detailed ‘colour schemes’ prescribed, depending upon the number of ‘masts’, for; they were all ‘sailing’ ships. A vessel with four masts was to be painted white, the one with three masts is to be given a red paint, a two masted vessel is to be colored yellow, and a one masted vessel was to have a blue color, etc.

The *Yukti-Kalpa-Taru* has been translated and published by Prof. Aufrecht in his “Catalogue of Sanskrit Manuscripts”. A detailed study of this, probably the ‘first ever’ treatise of Naval Architecture, has been undertaken by Dr. Radha Kumud Mookerji, in his book, “Indian Shipping”, (Published by Orient Longman, Bombay, in 1912). The original manuscript of this precious document is preserved in the Sanskrit College Library, Kolkata.

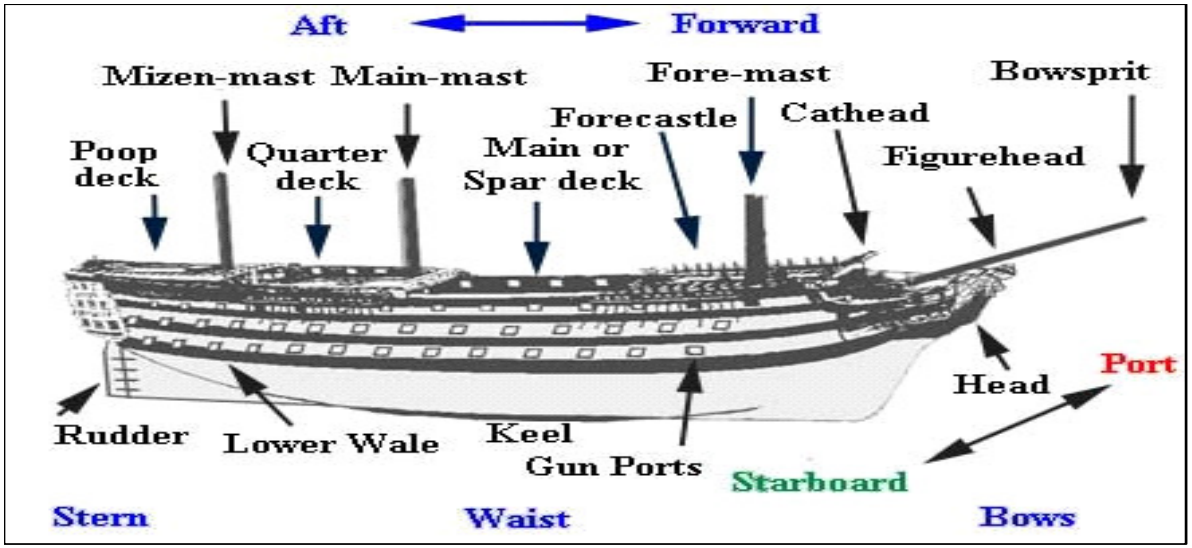
Yukti-Kalpa-Taru also gives classification of the then existing ‘ship-types’ : River-going ships – *Samanya*, meaning ‘ordinary’ & Ocean-going ships – *Visesha*, or ‘special’. Each is further divided & subdivided depending upon the size, type of construction, etc. According to the ‘location’ of the accommodation



Artist’s impression of a “Madhyamandira” Vessel

block, for instance, the ships were divided into three categories, the *Sarvamandira*, the *Madhyamandira*, and the *Agramandira*; 'Mandira', meaning 'apartments'. The *Sarvamandira* had passenger accommodation over most of the deck. In these were carried treasures, animals, and ladies of the court. This type of vessel was also used by the kings in times of peace. The *Madhyamandira* was so called because the living quarters were situated in the middle. It was a sporting vessel and generally used in the rainy season. The vessel of the third kind, the *Agramandira*, had the living room located in front or at the top of the vessel. The *Agramandira* was used for distant and perilous voyages and also for fighting wars at sea.

The term *Agramandira* is synonymous with the 'Fore-Castle' of the later day European ships. These so-called 'warships', right up to the 16th century, carried soldiers, who were accustomed to conducting sieges on land, as their offensive strength. The soldier ashore felt secure in his 'castle', although a castle is essentially defensive! And on going to sea to fight battles required that *castles* be provided in the ships of war. There were in fact two self-contained *castles* in these ships, one forward and one aft, known as the *fore-castle* and the *after-castle*. From these the soldiers fired the slingshot, longbow and crossbow. These castles almost disappeared with the advent of muzzle loading cannon due to increase in 'top-weight'… However, the name 'forecastle' has remained through the years, though often contracted in spelling and always abbreviated in pronunciation : Foxle, or F'cle.



A Typical Sailing Vessel of the 18th century

Throughout the ancient times and the middle ages until the 16th century, naval warfare relied on the ship itself, used as a ram, the swords of the crew, and various missiles such as bows and arrows and bolts from

heavy crossbows fixed on a ship's bulwarks. Naval warfare primarily involved ramming and boarding actions with the help of 'grappling hooks' etc. so warships did not need to be particularly specialized. However, the discovery of "gun-powder" and the creation of cannons, and guns, that took away the necessity of chivalry and eventually turned death into a gentleman's sport, with the rise of pistol duels; completely transformed the way wars were waged, and contributed to the eventual establishment of might over right. Gunpowder was the only explosive in wide use until the middle of the 19th century when it was superseded by nitroglycerine-based explosives.

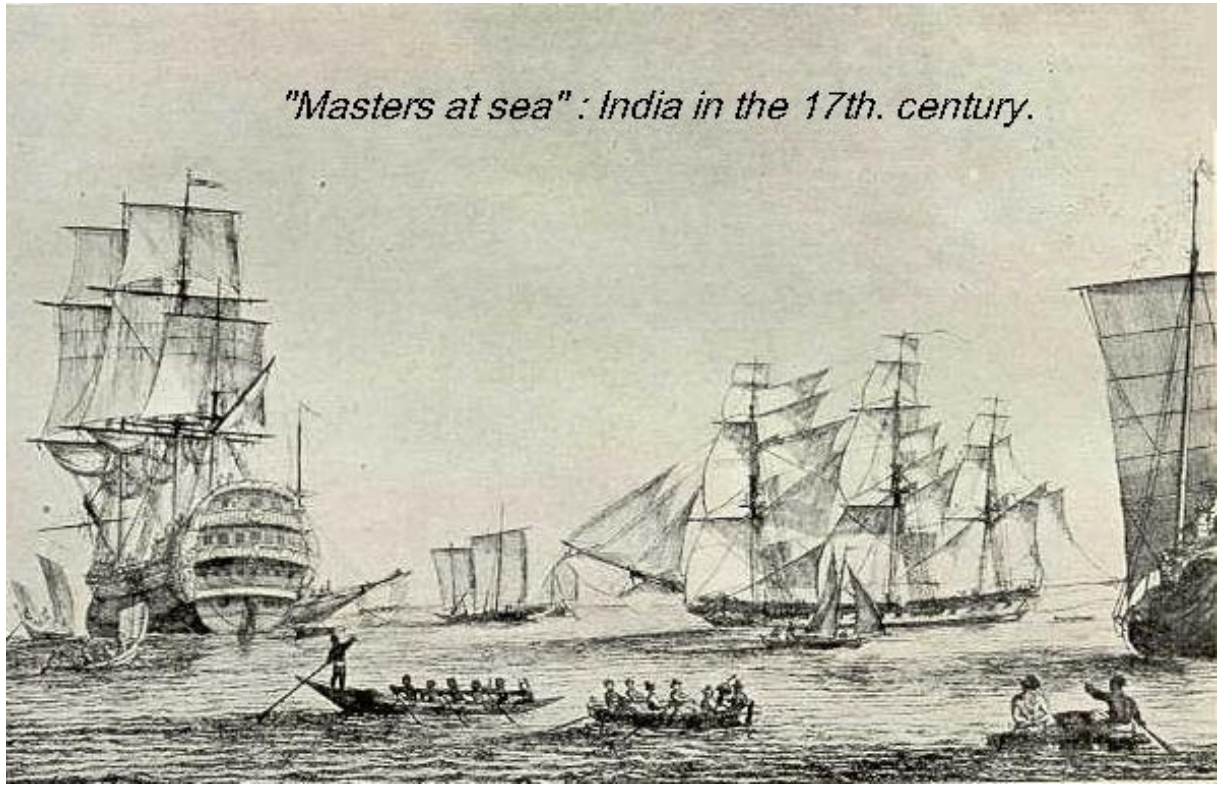
According to contemporary history, the Chinese are credited with the discovery of gunpowder, in the 9th century AD… By the 14th century it was supposed to have traveled to the 'west', in the caravans of merchants… Was first manufactured in England in 1334; and in Germany, in 1340. According to another account however, the gunpowder was first produced in India itself! "*Sukranitisara*", or "Sukraniti", a Sanskrit treatise on polity, on the same lines as the more famous "Arthasastra", gives the details of firearms that were being used in India using *agni-churna,* which was supposed to be identical in chemical composition & physical properties, to the gunpowder. Unlike "Arthasastra" however, the vintage of "Sukraniti" is not without controversy. It is attributed to *Sukracharya*, a Vedic sage, well versed in the art of polity; which would perhaps make it 'older' than "Arthasastra". A second group of researchers contends that the work has undergone several recessions and in its present form, it should be assigned to the 8th century. A few scholars call it a work of 1600 AD; & yet another group claims that it could well be a 19th century compilation, passed for a long time as a genuine ancient work! History is 'subjective; sometimes dangerously so.

Artist's impression of the Panipat battle

History also records that it was because of his "fire power" that Babur, the founder of the Mughal Empire in India, could win the battle of Panipat, in 1526. Though he had a much smaller army; the Indians were simply overwhelmed by the power of his guns & the cannons… They were obviously not aware of the 'gun powder' till that time! If so, the situation at sea could not have been different… & since Vasco-da-Gama landed in India, more or less at the same time, in 1498; it was perhaps, just the opportune time for the technically 'superior' invaders to plunder

India! And, to make matters 'easy' for them, there were the characteristic ever-continuing feuds between the local chieftains and kingdoms that facilitated the piecemeal subjugation of the coastal sections of India. "Unity" has never been India's 'power'!

In the era of wooden ships propelled by the wind, there was little difference between warships and merchantmen. Ships were usually built for merchant service and were easily converted and armed when required. Most were armed in any case for defense against 'pirates'. Countries would send out ships to guard their trade routes and allow the ship's crew to attack the competitor coming into their territory. The crew would sometimes attack every ship in sight, whether they were enemy or friend. The crew on these ships usually came to be called *Pirates*. The Indian Ocean has a 'history' of sea pirates!



From the earliest times in India, there had been three distinct, though widely separated regions where the naval power developed to a greater extent than elsewhere; for, naval endeavours are possible only in regions where the sea provides opportunities for harbourage, or in-lands that are washed by large and navigable rivers. These were, the Eastern coast, primarily Bengal; the West coast, including Punjab & Sindh, i.e. the Indus valley; and the extreme south of the Deccan peninsula, called Tamilakam, or, Tamilagam. By-en-large, the eastern and the southern coasts were always the home of fishermen & the sea-divers, seeking precious stones and carriers of maritime commerce from the earliest time. In the north-west, though the local warrior tribe Xathroi (Kshatri), had a good reputation in its early history; (for instance, it was responsible for supplying 30 oared vessels to Alexander, the Great, during his return journey); however, soon thereafter it started breeding a class of sturdy sea-rovers, particularly on the

western or the Malabar coast, who made 'piracy', their profession. The Malabar coast retained its piratical character up to the days of Shivaji. The numerous creeks and rocky islands along the coast, which had provided secure harbourage to the cruisers of these Konkan pirates, were subsequently converted into Maratha naval strongholds.

Shivaji, known as the founder of the last great Hindu empire, is also credited to be the first Indian ruler to build a systematic 'Naval force' in modern times. Shivaji believed in the doctrine "*Jalameva jasya, Balameva tasya*", meaning "One who controls the sea, controls the world…" This is exactly what Capt. Alfred Thayer Mahan 'discovered' in his well-known book, "The Influence of Sea Power Upon History", two hundred years later…

Shivaji proceeded to organize the first Indian 'Naval fleet' on modern lines. In 1698 Kanhoji Angray succeeded to the command of the Maratha navy & it was his continued harassment of British commercial interests (who hence called him a *pirate*) that 'accelerated' the pace of formation of the Indian Navy!

Birth of the Indian Navy

Although the ships designed & built in India, continued to 'hold sway' till the end of the 17th century, India had lost 'control of the sea' in the beginning of the 16th century itself. Just ten years after Vasco da Gama's ominous 'discovery' of the sea-route to India, the Portuguese were the first to lay claim to sovereignty over the Indian waters to project their national interests and influence! While the seas were regarded, by the Indians, & the Arabs, as pathways for carrying out maritime trade, the Portuguese considered themselves to be lords of the seas, which 'justified' the confiscation of the merchandise of all ships that sailed without their authority. Having consolidated their supremacy over the Indian Ocean towards the end of the 15th century, the Portuguese reigned supreme for nearly a century thereafter.

Painting of Indian built warship "Star of India

A relatively small naval battle, known as the Battle of Swally, off the coast of Suvali (anglicised to Swally), a village near the city of Surat, Gujarat, India, marked the beginning of the end of

Portugal's commercial monopoly, and the ascent of the British East India Company's presence in India. This historically important battle that took place on 29-30 November 1612, convinced the British East India Company to establish a small navy to safeguard their commercial interests from other European powers and also from pirates. It was named the "*Indian Marine*".

The Indian Marine got renamed "Indian Navy" for the first time, on 01 May 1830. There were quite a few 'changes' of the 'name' as well as the 'charter' subsequently. Finally, with effect from 02 October 1934, it became the "Royal Indian Navy", having the Naval Headquarters at Bombay, under the Flag Officer Commanding Royal Indian Navy. A Naval Liaison Officer was positioned at New Delhi from October 1939 onwards & in March 1941, the Naval Headquarters was itself transferred from Bombay to New Delhi.

The British, however, regard 05 September 1612, as the foundation day of the Royal Indian Navy, because it was on this day that a squadron of the warships arrived in India for the first time and the "*Indian Marine*" was formed. Soon after the arrival of the British squadron of ships at Surat on 05 September 1612, many Britishers arrived there and set up factories and a shipyard for repairing and building ships. The shipbuilders at Surat mainly comprised Parsis, the traditional ship designers & builders, who turned out to be excellent gunsmiths as well. Several ships were built and repaired at Surat for well over a hundred years. In 1735 the shipyard was shifted to Bombay because of its strategic position, considerably wide range of tides, and proximity to a large anchorage naturally protected from the sea. And it was Lowjee Nusserwanjee Wadia, the foreman of the yard & the ancestor of a long line of the famous Parsi master-builders of ships, who selected the site at Bombay, which is now the Naval Dockyard. During the course of the next 100 years this yard proceeded to build not less than 115 war vessels and 144 merchant ships, including 84 gun-ships for the Royal Navy, before the 'Indian shipbuilding' itself came under the 'Royal gun'! Simply because, the Indian ships were superior to the British built ships, in terms of

The Wadia Master builders - Maneckji Lowji Wadia, Jamsetji Bomanji Wadia

their durability, strength, seaworthiness and their imperviousness to seawater-borne worms… (In fact they were so good that the Admiralty started placing orders on Bombay that provoked the historical strike among the Thames Shipbuilders! It is remarkable that the oldest British warship in existence even now, H.M.S. Trincomalee that was renamed T.S. Foudroyant in-between, based on Nelson's famous ship, & is now restored as a floating museum, back with her original name, was built, at the Bombay dockyard, in 1817)… And this was not in the interest of the British shipbuilders!

With 'Independence', however, came the division of the Royal Indian Navy into the Royal Indian Navy (**RIN**) and Royal Pakistan Navy. The RIN continued to rely on the Royal Navy for its assistance for quite a few years, in the form of loan service of officers to man appointments at various levels, including Chiefs of the Naval Staff. On the 26th January 1950, RIN became IN, the Indian Navy; however, it was only in 1958 that Vice Admiral RD Katari took over as the first Indian Chief of Naval Staff of the Indian Navy.

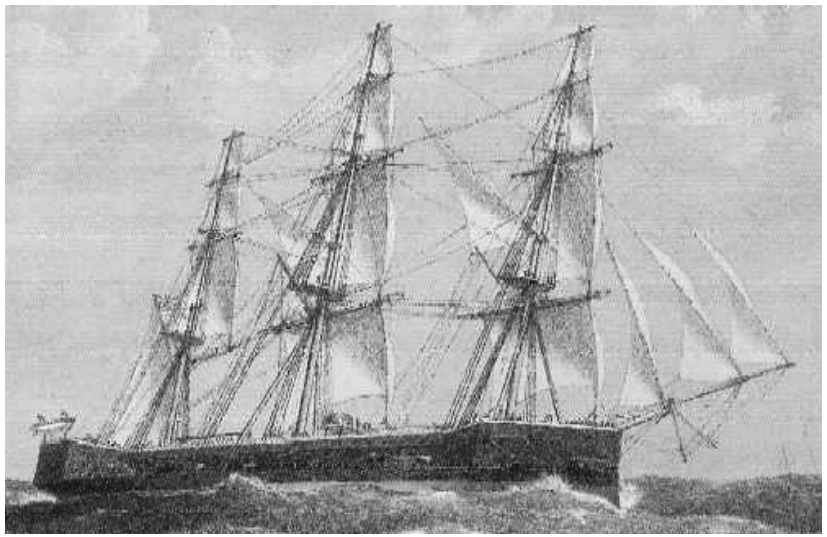
HMS Trincomalee

The 'Royal Corps of Naval Constructors' **:** During the days when the British glory was at its peak, the popular saying was : "*The sun never sets in the British Empire*"… What is not often realized is the fact that the British glory was the Empire itself that was created and later sustained by the British Navy, i.e. the Royal Navy… And that, there were just two things that enabled the sun to keep shining over the Empire all the time; the ships of the Royal Navy, & the people behind them… those who sailed in them — & those who designed & built them — the *Royal Corps of Naval Constructors*! And, it is the same winning combination, that, in the last fifty years, has turned the Indian Navy from a "Buyers' Navy" into a "Builders' Navy".

Naval Constructor, is the generic term used to describe warship designers in Europe. 'Constructors' descended from 'Shipwrights'; as a natural consequence of scientific approach being applied to shipbuilding as an 'industry'… on the erstwhile artisanal production methods, which were based solely on experience. It is the Defence R&D that invariably triggers the scientific growth of a country!

French were the pioneers in forming the first professional corps of naval constructors. The Génie Maritime, as it was known (*génie* means both, *engineer* and *genius*), was formed in 1765, and was marked by a rigid system of application into the corps, including the training in shipyards and education in engineering, and a formal system of advancement based on technical merit. The Génie Maritime became the model for the naval construction corps of many countries, including Spain, the Netherlands, Japan, and Britain. The constructors of the Génie Maritime operated autonomously, each in their own shipyards, until 1895, when ship design was centralized into one bureau. In the 1930s it subsumed the Naval Artillery Corps, and in 1961 it became known as the Direction des Construction Navales (***DCN***) and was incorporated into the centralized military procurement agency now called DGA.

The Royal Navy was actually slower to adopt the model of the Génie Maritime than other navies, in part because it was producing "successful" ships without a formal Corps! The first efforts began in 1805 under a Commission, which sought to rectify the perceived *inferiority* of British warships by, among other things, establishing a formal educational system for its constructors. This effort was short lived, and it was only in 1864 that a permanent school at Greenwich was created. Although British constructors often led the world in technological innovations, it was not until 1871 when HMS Captain a non-constructor designed battleship sank with almost all hands, including the designer, a retired gunnery officer, and an inquiry board found that the Admiralty constructors were 'right' in rejecting it, that their struggle for professional recognition was fulfilled. In 1883, a professional body modeled on the Génie Maritime was formed, known as the Royal Corps of Naval Constructors (RCNC), whose chief was the Director of Naval Construction. His power gradually waned as both the Navy and the British Empire shrank after the second world-war. By 1993, the Ministry of Defence began consolidating the service acquisition agencies into a centralized joint Procurement Executive (PE).



Painting of HMS Captain

The United States did not have anything comparable to the great fleets of Britain and France until the late 19th century, and in its early years the Navy's ships were designed by a curious hodgepodge of

both government and private naval architects. Under the Bureau of Construction and Repair (BC&R), a Construction Corps of naval officers was established in 1866. However, formal instruction in ship design was not instituted until 1879, when graduates from the Naval Academy at Annapolis were selected to attend the RCNC School at Greenwich. For two decades, U.S. constructors were educated in UK, until 1901 when a course modeled on the Greenwich school was established at the Massachusetts Institute of Technology in Boston. It was only then that the U.S. Navy had a professional corps of officers that resembled the French and British, in terms of a professional cadre who received a uniform system of training and were held to a uniform standard. Just before the second world-war, the BC&R was combined with the Bureau of Engineering to form the Bureau of Ships (*BuShips*); at the same time, the Construction Corps was disbanded, thus moving ship design into the hands of civilian naval architects. BuShips eventually became the Naval Sea Systems Command (*NAVSEA*).

Career paths of Constructors differ among the countries. French constructors are military, though operate more as civilians and only wear uniforms in certain postings. Although British constructors are civilian, they have a military rank and must wear uniforms in certain postings. American constructors are civilian. In Britain and France, posts are rotated every few years, and promotions are handled rather like in the military—the new posting depends on the rank. In the United States, there is no rotation, and promotions come only with new jobs.

A fascinating account of the history of the Royal Corps of Naval Constructors, from 1883 to 1983, can be found in the book : "**A Century of Naval Construction**", written by Mr. DK Brown, RCNC. "…In the early years of the 19th century the Establishment did not appreciate the need for ships to be designed by fully educated & trained Naval Architects & preferred the rival claims of the 'practical' Shipwright or the seagoing Naval officer", he writes… "In consequence, the greater part of that century was a time of conflict in which the Naval Architect won a place of authority as much ***by imposing a ruthless selection process on candidates for the profession*** as by the outcome of some tragic disasters when his professional advice was neglected"… At the end of his detailed commentary on the subject of the HMS Captain episode, Mr. Brown concludes: "This story has been told at length because it marked the end of the amateur in ship design and achievement by the professional Naval Architect of real authority."

Designers at work

And, this story is being told at length here because the 'stories' of Constructors are more or less the same everywhere! They may or may not be interesting, but all such stories are 'important'; they provide a sense of 'belonging', for one! Besides, they invariably carry important 'lessons' from history & the history can be very un-forgiving if these lessons are ignored, for whatever reason.

Naval Architects Vs. Naval Constructors **:** Naval Constructors are essentially Naval Architects only — except that they are trained to design & build Naval ships! It is in fact the Naval ships that are fundamentally different from their commercial brethren, for; while the former carry weapons for defence from, or for fighting war with an enemy; the latter, on the other hand, carry cargo &/or passengers, for trading between friends. Thus, not only the design philosophies, even the construction processes in the two cases, turn out to be fundamentally different; & it is certainly not fair to 'compare' the cost & building-time of a warship, with that of the merchant vessel. It may however be of interest to understand the reasons behind the same.

In the days of the wooden ships, Naval vessels were much like their commercial counterparts. It was the 'cannon' that made the first major difference! The introduction of cannons onto ships led to the development of 'tumblehome', the inward slant of the above-water hull, for additional stability; as well as techniques for strengthening the internal frame. Since the aiming and firing the cannons was difficult, because the gunner had to predict the roll of the ship in order to hit the target; the 'pivoting turret', a device that allowed cannons and other large artillery to rotate in all directions, was soon developed. These revolutions, & the overriding demand for ships to be capable of operating safely in the open ocean, led to the documentation of design and construction practice, in what had previously been a secretive trade, and ultimately formalized the field of Naval Architecture as a "Technology".

Iron was soon adopted gradually, first to provide 'armour' protection, initially in small areas needing greater strength, then throughout. Steel supplanted wrought iron when it became readily available in the latter half of the 19th century. However, though the biggest warships

Docking facility at sea –Navy's Floating Dock in the A & N waters

became larger, heavier, and more sturdily constructed than commercial ships, the skills needed to build both kinds remained nearly identical till then. In contrast, today a modern warship requires much more highly skilled and specialized designers, as well as, the workers; there is a much higher ratio of white- to blue-collar workers than that found in commercial shipbuilding. Besides, warship building demands much greater engineering support, as well as the need to interact extensively with the Owners' surveyors, the Naval Overseeing team. Such high overhead and high skill base cannot be sustained by any yard that expects to build typical commercial ships at competitive prices. Exclusive naval shipbuilding yards, therefore, came into being.

The worldwide trend in prices for commercial ships is 'cyclical' in nature. Over the past two decades it has been 'downwards', because of fierce international competition and the increased shipyard productivity that competition has motivated… In fact, a commercial ship may take up-to half the man-hours to build in today's world-class shipyards, that it took 20 years ago! The warship price trend, however, has been continually 'upwards'. The gap in price between commercial ships and warships has therefore been consistently widening. Some of this inflation is of-course, a result of better and more expensive weapon systems and the compulsion to at least match the current state of the art! This is a vicious circle of sorts… it takes longer for a warship to be built… by that time some of the weapons are bound to become obsolete… which leads to a change in design, & therefore 'longer' building period, & so on.

A typical multiple docking operation at ND(V)

Developing the QR's or the "Staff Requirements" is in itself more challenging for a warship — for which multiple functionalities are required to be considered to meet a relatively uncertain threat — than for a tanker, for instance, which is intended to profitably transport a fluid product of some type. This leads to several differences in complexity between military and commercial ships & consequent disparity in design effort :

- ✓ Warships often have relatively large propulsion systems for the space available to accommodate them, and their electrical

Indigenously designed and built destroyer - INS Delhi

systems are required to be capable of greater loads;

- ✓ Weapon and sensor systems onboard warships have to be planned, and the number and placement of such heavy systems is required to be addressed to ensure that the ship's centre of gravity is not too high;

- ✓ Warships are generally heavily engineered to reduce weight and to maximize available payload and space. For example, they are typically designed with thinner plating and more numerous changes in plate thickness than would be found on any commercial vessel; the extra expense required for doing the same on a commercial vessel cannot be justified!

Besides, a warship has to meet more numerous & more demanding '*standards*' because it is required to operate not only on the open seas but also in combat zones. There are strict specifications for structure and shock; nuclear, biological, and chemical protection; various 'signatures', discussed later; fire fighting; damage control; and weapon storage and movement. Further, all such aspects of ship design are required to be integrated with weapon and sensor systems that commercial ships lack.

Construction of commercial ships is mostly a 'volume' business that depends on simple steel forming and welding processes repeated over and over, for; they are, for the most part, large steel boxes with relatively small and simple propulsion and navigation systems. The construction of warships involves the use of exotic materials, the installation of large amounts of high-value, sensitive equipment, and the satisfaction of more exacting standards. Also, the testing process for Naval ships is more involved because it has to reflect the high technology and technology density of the ships and take account of multiple possibilities for mutual interference of advanced electronic systems. Commercial ship owners are

Typical commercial vessel which is close to warships in complexity in design and construction

accustomed-to much simpler contracting, designing, construction, and testing processes than those that pertain in the Naval world.

The differences between Naval and commercial shipbuilding diminish, however, when comparing less complex warships and auxiliary vessels, (such as the oilers, supply ships, landing ships, etc.), with relatively more complex commercial vessels such as large research vessels, pipe layers, and LNG (Liquid Natural Gas) carriers. As these two 'classes' have many similarities with regard to high technology and technology density, they are often built and tested to similar standards. By-en-large however, a Warship Design-Team headed by the Naval Constructor, (civilian or in 'uniform'), has a greater 'burden' of "integrating" the design, than the commercial vessel design team headed by a civilian Naval Architect!

The term "*integration*" is important & needs to be clearly understood.

The 'design teams' in both the above-mentioned cases, include 'Specialists' other than Naval Architects; such as the specialists in Mechanical or Marine Engineering who assist the Naval Architect in all aspects of mechanical systems & equipment, e.g. selection of main & auxiliary propulsion machinery, pumps & pumping arrangements etc. While the specialists are "operators" & "maintainers", by education as well as training; the Naval Architects are "designers" & "maintainers"… The two roles are not only different; they cannot even be interchanged!

The team members with Electrical Engineering specialization play a similar role in respect of various electrical systems & equipment. And in case of warships, there are weapon specialists too! In the Indian Navy the weapon specialization has grown out of Electrical Engineering Cadre.

While the 'specialists' play their specific roles in the team, the overall 'integration' of all the 'bits-&-pieces' into one composite design remains, & rightly so, the responsibility of the Naval Architect… Ship Design being NOT a '*functional*' job, but the '*professional skill*' of the Naval Architect! But, as it happens in such cases, more often than not, the '*actors*' assume a higher stature, overshadowing that of the

A multi-disciplinary warship design team

'*director*'… In an increasingly competitive world, such eventualities can never be totally eliminated; what is important however is that the personal 'differences' within the team are not allowed to adversely affect the 'project' as a whole! The overall personalities of 'Project Leaders' therefore do matter... & this is where a Constructor officer of the Indian Navy, stands high above the civilian Naval Architect.

The Indian Corps of Naval Constructors

Unlike their European counterparts, the Indian Naval Architects did not have the 'good fortune' of inheriting the shipbuilding profession from their own ancestors. Thus, when India gained independence, there were no 'home grown' Naval Architects… & hardly any employment opportunity existed either, for the one odd person who 'chose' to return back to India after having done 'Graduation' in Naval Architecture from a foreign University! The only 'bright star' on the horizon was the newly built, first 'Indian' shipbuilding yard, at Visakhapatnam, called the Scindia Shipyard, (later renamed the Hindustan Shipyard Limited). The other important centers of, not so much 'shipbuilding', but 'ship-repairing' opportunities, were M/s. Garden Reach Workshops Calcutta, (later renamed Garden Reach Shipbuilders & Engineers, Kolkata), & M/s. Mazagon Docks Bombay, (now Mazagon Dockyard Limited, Mumbai); besides the Naval Dockyard Bombay and some privately owned yards on either coast, that had started building fishing trawlers, barges, powered boats and small craft. There was NO warship construction whatsoever!

Prior to the Second World War, Britain's Royal Navy was responsible for the overall maritime defence of India; the Royal Indian Navy was given the limited role of coastal Defence only, as a `Dominion Navy'. As a member of the British Commonwealth that India had chosen to remain, Britain had provided a few warships to India, against the sterling balances for the services that India had provided to Britain during the Second World War. These ships were maintained & repaired by the Naval Dockyard Bombay, with the help of officers & men on 'loan' from Royal Navy. A "Directorate-general of Shipbuilding & Repairs"

Picture of the Technical Assistant (Construction) building at ND(Mumbai), from where the Naval Constructors operated during the early days

was also around that had been set up during the 2nd World-war for converting merchant ships into warships. Maintenance & repairs of the RIN ships after the war was looked after by this Dte.-general, with the help of RCNC officers & other staff. In 1946, however, it was wound-up & by 1947, most of its staff had also returned 'back home'.

After independence therefore, the responsibility of ex-RIN ships fell on the 'technical' officers of the Naval Dockyard, which comprised of Marine Engineers, Electrical Engineers & Shipwright officers. The Shipwright officers were the Shipwright Artificer Apprentices (SWA), who had come up from the 'lower decks' through promotion to the officers' cadre of "Special duty" officers. The SWA's received their basic training from INS Shivaji, which was established in 1943 for training the Marine Engineers and all branches of Artificer Apprentices. Their subsequent training included : Naval Architecture, Shipbuilding, Ship-repairs and dry-docking. This being entirely a Dockyard training, was conducted at the 'Shipwright Training School', under INS Angre. The Shipwright officers, however, did not have adequate academic background to take the place of RCNC officers, who had, in fact, 'trained' them at SWA level. The need for direct recruitment of graduate Naval Architects through open advertisement, was therefore felt & between 1950-52 three in number Naval Architects were recruited into the Navy, on temporary basis; Sarva-shri S. Paramanandhan; SS Dotiwala; & VS Dhumal.

The Indian Navy was still headed by RN officers, (which

Shri S Paramanandhan

(Late) Shri SS Dotiwala

(Late) Shri VS Dhumal

(Late) Cmde VP Garg

continued till 1958), as also the Ministries of Defence & Finance, by 'Anglicized' Indians who were bigger bureaucrats than their British mentors! The general 'thinking' at the time of the independence was that India would continue to remain in the British Commonwealth and that, the 'reinforcements' would arrive from Britain and other parts of the British Empire to help India defend her frontiers in the event of any threat; Russia being perceived the only "threat" by the Britishers. Plans were being made to "buy" ships for replacement of existing old vessels, which also included possible 'expansion' of the Naval fleet, within the budgetary constraints. VAdm. Sir Mark Pizey, who took over as the CNS in 1951, floated a 'Ten-year Replacement Plan' for Indian naval ships, which also envisaged a modest indigenous 'Naval Construction' programme, comprising of minor vessels. A Directorate of Naval Construction was conceived & sanction obtained. And on 20th oct.'54 Capt. L. Kirkpatrick RCNC was installed as its first 'Director', (DNC). As a parallel activity, one number Indian Naval cadet who was already undergoing Marine engineering training in UK was diverted to undergo Naval Constructors' training there itself; & on completion there-of in 1954, he returned as Lieutenant VP Garg, the first 'uniformed' Naval Architect. By the end of 1954 therefore, the Indian Navy had five Naval Architects : three civilians, one uniformed & one RCNC, on loan from the Royal Navy.

In June 1955, the DNC floated the formal case for the formation of a Corps of Naval Constructors in the Indian Navy, with 20 civilian Naval Architects, including 2 numbers to take care of the TDLR element (officers on Temporary duty, Leave & Release). As expected, the proposed corps was to comprise of civilian Naval Architects, on the lines of RCNC, treating the single 'uniformed' officer as an 'exception'; but that the case would get stuck on the issue of 'pay scales', was least expected… The salary being offered to the civilian Naval Architects in the Navy, (Ministry of Defence), was less than that offered to similar candidates with, in fact, lower qualifications & experience, by the Ministry of Transport!

(Late) RAdm SM Misra, AVSM

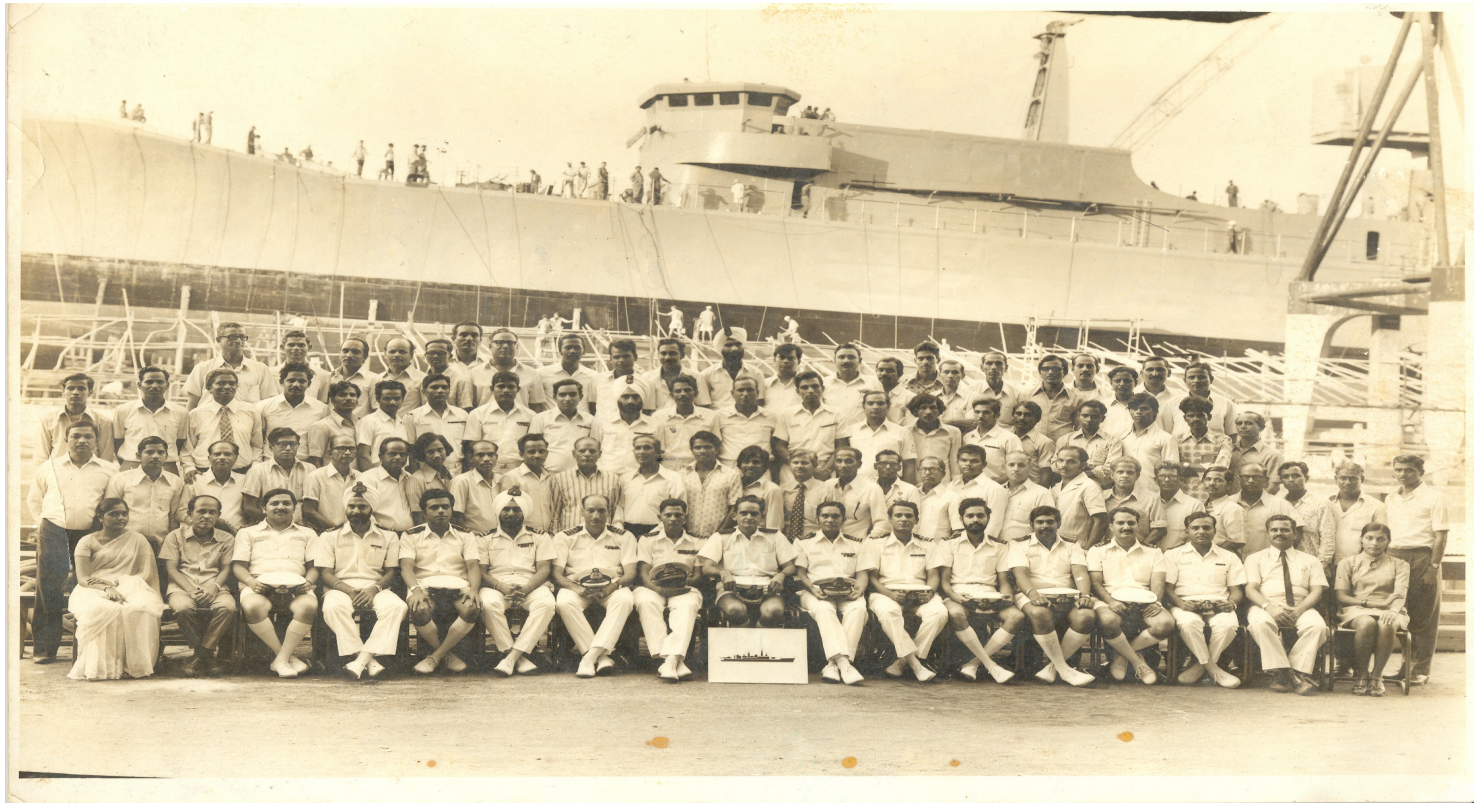
(Late)Cmde AN Thukral, VSM

Capt KK Lohana VSM

Cdr Prem Prakash

Since the Ministry of Finance was not willing to 'give-in', & the Navy was worried that it may 'lose' the three existing civilian Naval Architects, the proposal was 'revised' to build-up the corps with uniformed Naval Architects, treating the three civilians as exceptions!

After many interesting ups-&-downs, the sanction was received on the 11th March 1957, for a total 18 nos.-uniformed officers, (in addition to the three civilians & one uniformed Naval Architects that already existed), to form the stabilized cadre of Naval Constructors in the Indian Navy. On 04th June 1957, Capt. Kirkpatrick relinquished the chair of DNC on completion of deputation.



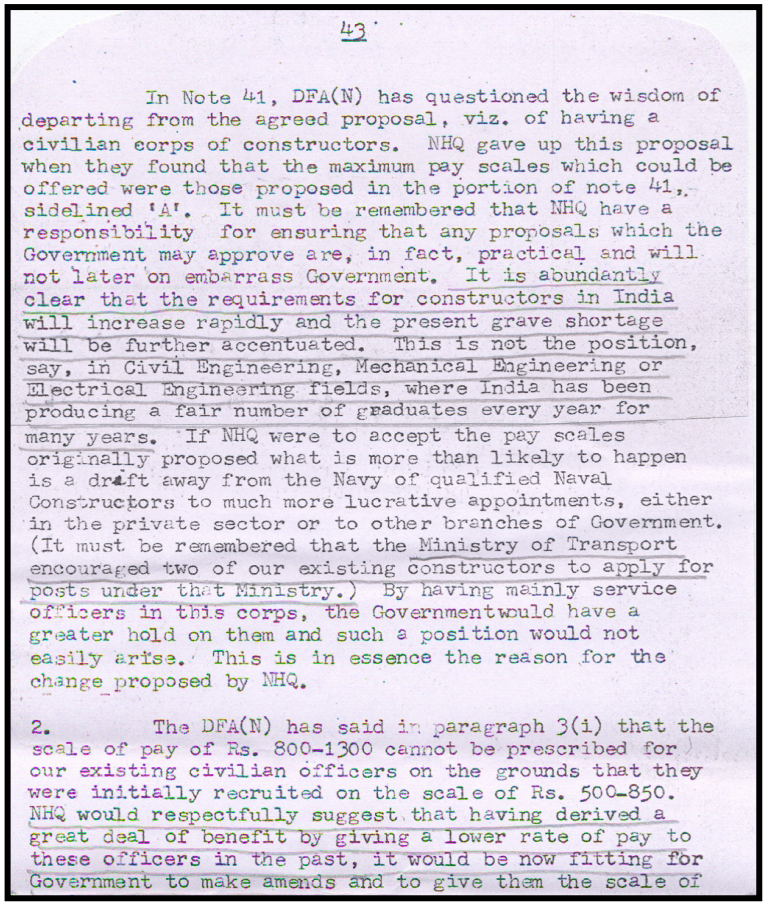
Admiral Misra, then Captain, as WPS(Bombay), on his farewell

Brief History of Formation of the Corps.

Year	Event
1946	The Directorate-General of Shipbuilding & Repairs, which was functioning from the Naval Dockyard Bombay, since the 2nd World-War, gets 'wound-up'.
1947	The RCNC officers & supervisory staff, on 'loan' from the Royal Navy, are repatriated, because of shortage of such personnel in the RN itself.
1950	Shri Subramanyam Paramanandhan, joins the Indian Navy, as the first Naval Architect! He is a 'gold medalist' in Mechanical Engineering from Guindy Engineering college India, with Post Graduation in Naval Architecture from Newcastle-upon-tyne, UK. Within the next two years, two more Naval Architects, Shri SS Dotiwala, (ex-Durham, UK); & Shri VS Dhumal, (ex-Michigan, US) also join the Navy. Another Naval Architect, Shri MA Elias Jones, also applies but does not join. Thus, by 1952 there are a total of 3 Naval Architects in the Indian Navy.
1954	The Government embarks on an indigenous Naval-construction programme, (arising out of 'Replacement-work' of existing ships); A 'Directorate of Naval Construction' is sanctioned & Capt. L Kirkpatrick, RCNC, on loan from the Royal Navy, takes over as the first DNC.
1955	Under the signatures of VAdm. Sir Mark Pizey, the then Chief-of-Naval-Staff, DNC takes up the 'proposal', (June 1955), for creation of a stabilized cadre of civilian Naval Architects, as the "Corps of Naval Constructors", on the lines of the Royal Corps of Naval Constructors.
1956	The case gets 'stuck' on the issue of Civilian officers being offered pay scales; lower than those being offered to Naval Architects, outside the Ministry of Defence. As a result, Navy forwards the 'revised proposal', (August 1956); Naval Architects to don Naval uniform on recruitment & form part of the Marine Engineering Branch, for 'Administrative Convenience'… "during the build-up period & until such time as development suggests otherwise".
1957	Pushed by the then CNS, VAdm. Sir Stephen Carlill, RIN, & the Chief of Material, (then) Cmde. Daya Shankar, DSC, IN, the Corps of Naval Constructors is sanctioned for the Indian Navy, (the letter is dated **11th March 1957**, but the Corps 'formation day' is **23rd November 1956**, vide amendment dated **20th July 1957** to the sanction letter).

Thus, November 23rd is the Corps' date of birth! Though the Corps was conceived on the lines of RCNC, it was different 'as born' & had its own distinguished entity, different from the Constructor cadres of all other Navies, which it continues to enjoy.

The Earlier 'Vision' **:** Vice-Admiral Daya Shankar, who was then the Chief-of-Material in the rank of Captain, & later Commodore, was the chief architect of the revised proposal. His involvement & commitment to the cause of the Corps, is palpable from his numerous notings on file, to the various Naval authorities, & Ministry. A 'sample' noting reproduced below that gives an insight into his vision as also the logic behind 'revising' the original proposal, speaks for itself.



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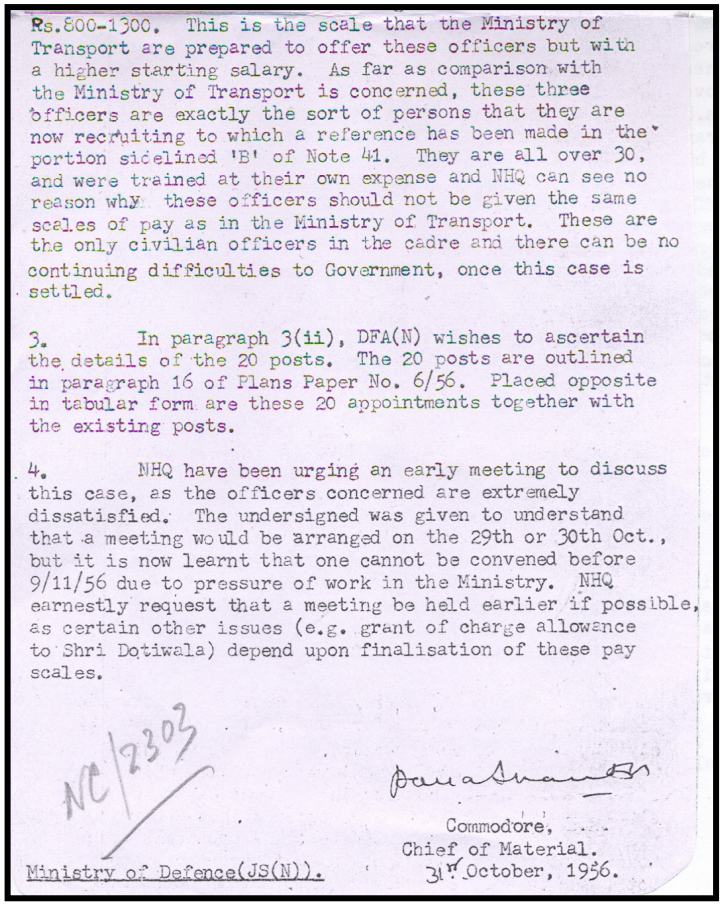
In Note 41, DFA(N) has questioned the wisdom of departing from the agreed proposal, viz. of having a civilian corps of constructors. NHQ gave up this proposal when they found that the maximum pay scales which could be offered were those proposed in the portion of note 41, sidelined 'A'. It must be remembered that NHQ have a responsibility for ensuring that any proposals which the Government may approve are, in fact, practical and will not later on embarrass Government. It is abundantly clear that the requirements for constructors in India will increase rapidly and the present grave shortage will be further accentuated. This is not the position, say, in Civil Engineering, Mechanical Engineering or Electrical Engineering fields, where India has been producing a fair number of graduates every year for many years. If NHQ were to accept the pay scales originally proposed what is more than likely to happen is a draft away from the Navy of qualified Naval Constructors to much more lucrative appointments, either in the private sector or to other branches of Government. (It must be remembered that the Ministry of Transport encouraged two of our existing constructors to apply for posts under that Ministry.) By having mainly service officers in this corps, the Governmentwould have a greater hold on them and such a position would not easily arise. This is in essence the reason for the change proposed by NHQ.

2. The DFA(N) has said in paragraph 3(i) that the scale of pay of Rs. 800-1300 cannot be prescribed for our existing civilian officers on the grounds that they were initially recruited on the scale of Rs. 500-850. NHQ would respectfully suggest that having derived a great deal of benefit by giving a lower rate of pay to these officers in the past, it would be now fitting for Government to make amends and to give them the scale of



Rs.800-1300. This is the scale that the Ministry of Transport are prepared to offer these officers but with a higher starting salary. As far as comparison with the Ministry of Transport is concerned, these three officers are exactly the sort of persons that they are now recruiting to which a reference has been made in the portion sidelined 'B' of Note 41. They are all over 30, and were trained at their own expense and NHQ can see no reason why these officers should not be given the same scales of pay as in the Ministry of Transport. These are the only civilian officers in the cadre and there can be no continuing difficulties to Government, once this case is settled.

3. In paragraph 3(ii), DFA(N) wishes to ascertain the details of the 20 posts. The 20 posts are outlined in paragraph 16 of Plans Paper No. 6/56. Placed opposite in tabular form are these 20 appointments together with the existing posts.

4. NHQ have been urging an early meeting to discuss this case, as the officers concerned are extremely dissatisfied. The undersigned was given to understand that a meeting would be arranged on the 29th or 30th Oct., but it is now learnt that one cannot be convened before 9/11/56 due to pressure of work in the Ministry. NHQ earnestly request that a meeting be held earlier if possible, as certain other issues (e.g. grant of charge allowance to Shri Dotiwala) depend upon finalisation of these pay scales.

NC/2303

Daya Shankar

Commodore,
Chief of Material.
31st October, 1956.

Ministry of Defence(JS(N)).

A rare picture of Admiral Daya Shankar, as a Lieutenant in the Royal Indian Navy. Lt. Daya Shankar was the engineer officer on-board HMIS Lawrence in the Persian Gulf during the second world war. Lawrence had been ordered to board the Italian vessel Caboto which had been set on fire by her crew in an attempt to scuttle her. Lieutenant Shankar boarded the blazing ship, captured the crew and then proceeded to not only search for scuttle charges but also to assist with the fire fighting. He was awarded Distinguished Service Cross for his act of bravery.

No consideration had obviously been given at that time, to the possibility of building major war vessels such as Frigates or Destroyers in India; indeed such a scheme could not have been a practical proposition in the 'fifties'. From 'sixties' however, the situation changed rather rapidly, starting with the acquisition of the Mazagon Dock & Garden Reach shipyards by the Govt. The 'heavy' industries were fast developping under the five-year plans & the prospect of future expansion of India's industrial capacity was clearly visible. To top it all, there was the Chinese aggression in 1962 & then the 1965 war with Pakistan that finally turned the table in favour of greater attention to be paid to in-house naval-ship building capability. Admiral Daya Shankar, however, was not available to steer the corps as he had retired by then. The mantle fell on the shoulders of Shri Paramanandhan, who, as the then Staff-Officer under DNC, had played a major role in revising the original proposal.

Right from conception the vision for the corps laid emphasis on the "career prospects" of the Naval Architects joining the Navy… it was a precious commodity that needed to be nurtured! Since the total number of Constructors was only 22, (3+1+18), & was not 'expected' to grow very much more, at least in the near future, the Constructors were grouped alongwith the Marine Engineers, "during the build-up period & until such time as development suggests otherwise". This 'administrative decision' was taken considering that only the most brilliant engineering Naval-cadets were allowed to become Constructors, which followed by extensive training that was required for their profession, which was time-consuming… & expensive! It was therefore considered necessary to ensure that more promotional opportunities were available to them, which should have been possible if they were part of a bigger cadre! There were occasions however when this did not happen though… Admiral Misra & Capt. Lohana had to be deputed out of the Navy to get promotions & Cdr. Deans & Cdr. Prakash had to leave the Navy as they did not get promoted… Not because they lacked competence! Both these officers would have contributed substantially in the subsequent Naval construction programme of the Indian

Captain Lohana speaking on his farewell from MDL to DGND on reverse deputation. Others in picture are Shri Dotiwala (right) and Capt Mohan Ram.

Navy. In fact, they performed exceedingly well in Canada & Norway respectively! Loss of the Indian Navy was another country's gain. Since there are always only a limited 'vacancies', promotions on the basis of 'seniority' in Service, are bound to result in the 'cream' flowing-out!

Again, from the 'career prospects' angle only, in order to ensure that there will be no 'stagnation at the top', the 'recruitment process' was over-cautious & therefore very slow. The initial few batches comprised of the 'toppers' from the Marine engineering cadets. From 1952 onwards the newly established Indian Institute of Technology (IIT) Kharagpur, started offering a five & a half year course in Naval Architecture. (It is a 4 year course now!). Thus, from 1958 onwards, 'Direct entry' Naval Architects also started joining the Corps. They were all required to undergo another three year course at the Royal Naval College at Greenwich, UK. (University College London with effect from 1964). It took 13 years to reach the magic figure of 22 officers, (18 + 3 Civilians + 1 in uniform)!

Admiral Perira, the Chief of the Naval Staff, with ND(V) officers, 1980

Cadre Strength by 1954 (before formal "Sanction")
Total strength of NC officers = **4** including the three civilian Naval Architects **+** One Cadet-entry Marine Engineer officer, (Late Cmde.) VP Garg.

Officers Joining the Corps. from 1954 to 1966

Year	No.'s (& Type)	Names of the Officers
1954	2 (Cadet entry)	(*Late RAdm.*) SM Misra; (*Late Cmde.*) AN Thukral
1955	2 (Cadet entry)	(*Cdr.*) DCJ Deans; (*Capt.*) KK Lohana
1956	2 (Cadet entry)	(*Late Capt.*) SK Kapur; (*Cdr.*) P. Prakash
1957	-	-
1958	2 (Direct entry)	(*Cmde.*) MK Mukherjee; (*RAdm.*) PV Damodaran
1959	2 (Direct entry)	(Capt.) NS Mohanram; (*Cdr.*) SR Kamath
1960	-	-
1961	-	-
1962	2 (Cadet entry) + 2 (Direct entry)	(*RAdm.*) RK Whig; (*Cdr.*) DS Arora (*RAdm.*) RS Chaudhry; (*Lt. Cdr.*) S Banerjee
1963	-	-
1964	2 (Direct entry) + 1 (Cadet entry)	(*Capt.*) J Subbiah; (*VAdm.*) R Nath (*Capt.*) KC Debrass
1965	-	-
1966	1 (Direct entry)	(*RAdm.*) M Raman

Total = 18 officers joined the Corps. in **13** years
Grand Total upto 1966 = 22

Directorate of Naval Construction **:** The Directorate of Naval Construction turned out to be the most 'productive' Directorate in the Indian Navy; a real 'parent'! Over the years it has given 'birth' to :

- The Warship Overseeing Team at Mazagon Docks Bombay, in 1965;
- The Directorate of Acquisition Project (DAP), in 1968;
- The Directorate of Leander Project (DLP), in 1969, which subsequently became Directorate of Naval Ship Production (DNSP);
- The Directorate of Naval Design (DND), in 1970, which, got upgraded to the Directorate-general of Naval Design (DGND), in 1976;

Shri Paramananandhan, Capt Lohana, Admiral Damodaran and Prof Gokarn(of IIT, Kharagpur, in a conference at Visakhapatnam(1988).

- The Directorate of Naval Architecture (DNA), to which it got converted in 1985.

DNC was established to take care of all aspects of naval construction; it was also the nodal agency at Naval Headquarters, for the acquisition & induction of all ships from abroad. Although it was not expected to undertake complete design of major war vessels then, it was required to keep all the drawings & documentation for existing, as also acquired vessels, curated & updated, incorporating various alterations/additions & modifications, besides itself examining relevant modification proposals & making the necessary drawings.

From 1970 onwards, the "Design" function of the Naval Constructors, & indeed of the Navy as a whole was taken over by DND, which grew two 'wings' on being elevated to DGND in 1976; the "Surface ships Design Group", (*SSG*), & the "Submarine Design Group", (*SDG*). Both wings have Marine Engineers as well as Electrical Engineers, in addition to the Constructor officers… more or less on the lines of the existing RCNC, which also comprises of Mechanical & Electrical engineers, in addition to Naval Architects, as a single corps, except that in case of RCNC they are all civilians. In case of DGND, the administrative 'control' of individual uniformed officers rests with the concerned 'Professional Directorate'.

The DNA, (erstwhile DNC), continues to be the 'Professional' Directorate for the Corps of Naval Constructors, just as the DME had been for the Corps of Marine Engineers, or, the DEE for the corps of Electrical Engineers; maintaining the separate entity of the Naval Architects amongst the 'technical' cadre, as envisaged by the Navy & accepted by the Govt.

The early Constructors **:** With the formal 'regularization' of civilian Naval Architects, Shri Paramanandhan became the first officer of the corps of Indian Naval Constructors. He was followed by Shri Dotiwala, Shri Dhumal & Commodore Garg… in that order. These four officers turned out to be four pillars of the corps. Shri Paramanandhan was the doyen of ship-designers who placed warship-design on solid foundation in the Indian Navy, & indeed in the country. Shri Dotiwala strengthened the warship-construction activity as 'Director Shipbuilding' at the Mazagon Docks. Shri Dhumal was responsible for initiating the 'Construction Supervision' activity in naval ship construction. Commodore Garg took care of the administrative back up… for the cadre as well as Naval construction! Amongst his various other contributions, he authored the 'standard contracts' for 'ship repairs' & 'new construction' in the Indian Navy.

The next three batches of officers, brilliant Marine Engineering cadets, trained as Constructors, carried-on the good work done by the four pioneers. Admiral Misra turned the sickly Garden Reach Workshop into a highly productive Defence yard. Cmde Thukral did the same for Mazagon Docks. Cdr. Deans & Cdr. Prakash added to the efficiency of Naval Dockyard Bombay. Capt. Lohana set up the Design Dept. of MDL, worked out effective technology transfer to Garden Reach & took charge of Naval Designs from Shri Paramanandhan on latter's retirement from active service. Capt. Kapur strengthened the Goa Shipyard.

Amongst the early Direct-entry officers, Cmde. Mukherjee & Admiral Damodaran provided the much-needed support to indigenous R&D activities & the in-house training of Constructor officers. Capt. Mohan Ram systematized the design process, gave confidence to the designers & together with Capt. Subbiah, brought credibility to the Corps of Constructors.

Discussion on design concept …

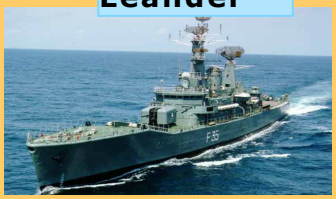
From the subsequent batches, Admiral Whig gave a new look to the Cochin Shipyard, which is presently building the prestigious Aircraft Carrier for the Navy, being designed by DGND… Admiral Chaudhry laid the foundation of indigenous Submarine design in the Indian Navy…

Thus the story of Naval Construction in India is the story of these pioneers in the Corps of Constructors of Indian Navy. While in this book that tracks the collective contribution of the Corps, to the Navy & to the Nation at large, individual contributions will find a mention as appropriate; detailed discussion on specific contributions of individual officers, their lives & times, has to be the subject of another book in this series. Contributions of others too, like the civilian Design-officers in the NHQ & other Commands, Technical-Assistants in the Dockyards & Naval repair establishments, & the Shipwright officers, who are the extensions of the Corps, will find place in such an outlet.

Developing the details…

Evolution of Naval Construction In India

Leander



Godavari

Brahmaputra

Delhi

LST

Tug

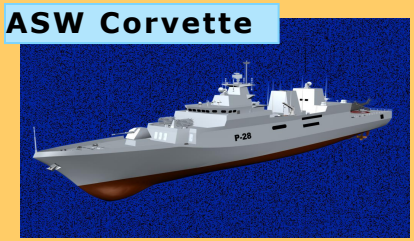
Khukri

Survey Vessel

SDB

Submarine

ASW Corvette



Stealth Frigate

Air Defence Ship

The First Decade : 1957-1966

By the time Capt. Kirkpatrick left in 1957, a 'Drawing office' was well established in DNC. It was headed by the British draughts-men & manned mostly by ex-dockyard apprentices who continued the good work after the Britishers left. One of the earliest major tasks undertaken by DNC was related to the construction of IN Survey ship *Darshak*, the order for which was placed by the Navy on M/s. Hindustan Shipyard (HSL), in 1954. This was based on the design of an existing French vessel; however, HSL was still new to shipbuilding & had a lot of 'queries'. These were taken care-of by DNC, who coordinated with DME & DEE within NHQ. As the quantum of work increased, in 1962 a 'Design Cell' was created within the Directorate, which undertook all other 'conversion' & 'modification' work, besides the design of auxiliary vessels like the Yard crafts, Harbour crafts, Seaward Defence Boats etc. Due to various difficulties however, HSL's work on *Darshak* got delayed & the ship could finally be commissioned in 1964 only.

In 1965, separate sanction was obtained for a 'Central Design Office' (CDO), with "C", "E" & "L" elements, ('Constructor', 'Marine Engineer' & 'Electrical' officers), & the "Design Cell" was converted into CDO. It got further expanded to become DND in 1970 & finally DGND in 1976.

Capt. TN Kochar took over from Capt. Kirkpatrick as the first Indian DNC in 1957. He was an "E" officer, partially trained as Constructor at UK. His pioneering efforts to

establish links with the Dept. of Naval Architecture & Marine Engineering at IIT Kharagpur resulted in setting up of the 'Naval Construction Wing' (NCW), in 1967. The sanction for setting up the NCW at IIT Kharagpur was obtained during the time of Capt. BP Sinha, another "E" officer, with 'Dagger' qualification from UK, who took over from Capt. Kochar, in 1961. He was also a Bar-at-Law & was instrumental in finalizing the 'Agreement' with Britain for the construction of Leander class frigates in India, which was concluded in 1964. By then Shri Paramanandhan had taken over as the first Constructor DNC. Before taking over as DNC, Shri Paramanandhan was the Assistant Industrial Manager (Construction) at ND (B). On the 22nd March 1963, he created history by docking the aircraft carrier INS Vikrant in the Cruiser Graving dock, at ND (B). This was a meticulously worked out operation of tremendous precision. Using scaled wooden models the dock walls were modified to accommodate the oversized hull, with the sponsons literally 'crawling' over the dock. The clearances were in inches! Almost all the senior Naval officers came to witness the miracle. The 'feat' was the announcement : "Constructors have arrived"!

Thus the first decade from 1957 to 1966, may be called the period of '***Conception***' for the Corps. DNC with its meager complement contributed in the construction of one number survey ship (*Darshak*), six Seaward Defence Boats (*Ajay*, *Abhay*, *Akshay*, *Amar*, *Ajit*, *Atul*), two wooden Mine-sweepers (*Bhatkal*, *Bulsar*), & a fleet tug (*Balshil*); in addition to the design (& construction) of a number of auxiliary vessels

including Harbour Utility tugs, Landing Craft Utility, Oilers, HSD Tanker, Water barges etc. It carried out 'updation' of all British drawings, without any guidelines whatsoever & with tremendous 'material' problems as all stationary & drafting paper was imported! There was no technical library and absolutely no reference material other than the personal notes that the officers had prepared during their course abroad. Notwithstanding all that, the DNC prepared drawings for various 'modifications' that were carried out on IN ships, such as *Vikrant*, *Dharini*, *Magar*, etc. & also assisted in the construction of the new Fleet Tanker *Deepak* in Germany.

The first major opportunity came in 1965 when the overseeing of the construction of the frigates being built at Mazagon Docks was entrusted to the DNC & Shri Dhumal took over as the first 'Officer-in-Charge' of the Warship Overseeing Team in Bombay. A 'Leander Project Cell' was established with in the DNC, which was hived-off in 1969, to become the Directorate of Leander Project (DLP). It became the Directorate of Naval Ship Production (DNSP), in due course. Prior to that, in 1968, the management of the Russian Acquisition programme was also taken-off from DNC & off-loaded to a new Directorate of Acquisition Project (DAP). Shri Paramanandhan was on deputation during this period; in 1967 he was deputed as Director Shipbuilding, to 'streamline' the shipbuilding process at HSL. He returned in 1970 as DNC (Designs), in-charge of the CDO, which was soon renamed, DND.

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Leander Class frigate - First indigenously built warships

The 2nd Decade : 1967 – 1976

The 2nd decade, from 1967 to 1976 was the period of '***Consolidation***' for the Corps… And the 'Leander Project' was the 'launching pad' that proved to be the foundation for future growth of Naval construction in India!

The Indian Govt. had accepted the need for procurement of eight Leander class Frigates from UK. This was to match the growth in the Naval Fleet of Pakistan, as a result of the direct US aid to them. Providentially, it was decided that three of the Leanders are to be built in India, by MDL, in collaboration with M/s. Yarrow & Co. Ltd. & M/s. Vickers' Armstrong Ltd., UK. After the contract agreement was finalized in 1964, in which the then DNC had played a major role, being a qualified Bar-at-Law, the order for the first Leander, INS Nilgiri, was placed. The Prime Minister, Mrs. Indira Gandhi, laid the 'keel' at MDL Bombay, on 15 Oct.'1966. Fortunately, she was also there to launch the vessel on 23 Oct.'1968; (& for 'commissioning' on 03 Jun.'1972, too!). On her return to New Delhi after the Launching ceremony, the Prime Minister issued directive that the Navy's Design organization should be strengthened on urgent basis so that it can quickly produce more designs of future Naval vessels, with most modern propulsion packages etc. The directive also stressed the need for closer & timely coordination between the ship designers & ship builders. This resulted in 'self reliance' in the fields of warship design & production being one of the major objectives of the 1969-74 Defence Plan. It also helped in getting the sanctions for, first, the Directorate of Leander Project (DLP), in 1969, followed by the Directorate of Naval Designs (DND), in 1970.

Capt. Mohan Ram, then a Lieutenant, was selected as member of the team that was sent to the British Navy's Director General Ship Design Office at Bath to study the design philosophy of the Leander class frigates. By the end of his two-years' attachment Capt. Mohan Ram had collected a gold mine of design data on all aspects of ship design & was magnanimous enough to share his treasure with fellow designers on return. The photostat copies of the "General Hull Specifications" (GHS), & the "Air-conditioning/Ventilation General Handbook" (ACGH)

Shri Paramanandhan and (Late) Cmde Thukral in a meeting at MDL

brought by him were used like 'Bibles' for many generations of Constructors. It was not until 1987 when another group of Constructors managed to 'import' two complete sets of the precious Naval Engineering Standards (NES's) on-board INS Virat, that the Navy's Design organization could claim complete self-sufficiency in Naval design documentation, specifications & standards.

Due to foreign exchange crunch the order for building the 2nd & 3rd frigate had to be delayed; it was placed in 1967. The Navy took the opportunity to upgrade the Radar & Fire-control systems, from *British* in Nilgiri to *Dutch* in the remaining Leanders. It was found that to fit the Dutch equipment, the ship would require some modifications in the hull and in the structure; this was related only to these equipments and not to a wholesale change of design. The modified shipbuilding drawings were obtained from NEVESBU, the Dutch Warship Design Bureau. Admiral Whig, (then Cdr.) was a member of the team that was deputed to NEVESBU for a period of 18 months. On return, he introduced the culture of 'detailed working drawings' in the Navy. This led to 'standardization' of design, cutting down on in-fructuous work & expenditure.

In 1972 it was felt that the British Mortar Mk 10 anti-submarine ahead throwing weapon fitted in the aft well were not very useful; it was therefore decided to remove them and cover the well. This was the first major structural change that was under taken by the Navy, in house. Having removed the Mortar MK 10 the anti-submarine capability of the ship was reduced. The Navy wanted to modify the aft portion completely to accommodate *Seaking* anti-submarine helicopter in lieu of *Alouette*. The modification involved complete review of the structural strength and stability of the ship. Since only limited design data was made available for construction of Leander class frigates in India, MOD Navy, UK were approached. They however replied that this modification is not possible as Leander Class frigates are too small to carry *Seaking* helicopters.

A Leander class frigate

The challenge was accepted, by Admiral Misra, then DDLP as Cdr; & Cmde. Bhatia, then Lieutenant! The entire aft structure of the ship was redesigned, from basics, for safe landing of *Seaking* Helicopter weighing many times the *Alouette* helicopter. Necessary changes were made for ensuring the stability and the trim etc. In addition a Swedish *Bofor SR375* twin rocket launcher was also provided, forward of the Gun mounting, as desired by the Naval Staff. Subsequent design of the flight deck & the hangar was undertaken later; by Admiral Chaudhry, & Capt. Mohan Ram, who made the hangar 'collapsible'! On implementation of the modifications the 5th and 6th Leanders became the smallest ships in the world to carry *Seaking* helicopters & collapsible hangars!

High level delegation to Soviet Union

The Leander Project also resulted in large-scale indigenisation & indigenous-substitution of components, equipment & material… indigenisation is when an identical product is developed to replace the existing imported item, whereas indigenous substitution occurs when a piece of equipment performs the same function to the same or higher performance criteria as the substituted equipment without being absolutely identical. DNC played crucial role in indigenisation of steel. A special weld-able steel, known as Ship Building Quality Steel or Lloyd's grade A/ B is used in shipbuilding. These steels were not manufactured in India till then. The issue was taken up with the Ministry of Steel & the Rourkela Steel Plant. After several attempts, finally the steel produced was considered acceptable and used in constructing the second Leander. Subsequently, it was found that imported steel was cheaper & available more quickly; the same was therefore used for later ships. It was however useful having established an indigenous source of manufacture of shipbuilding quality steel, which was made use of later… during the indigenisation of Soviet steel.

VAdm. GM Hiranandani (Retd). gives a graphic account of Navy's Leander Project, & indeed of all subsequent projects of the Indian Naval designers, upto 1990, in his two remarkable books covering the unclassified history of the Indian Navy, "Transition to Triumph" & "Transition

to Eminence". About the Leander Project Admiral Hiranandani writes : "The enormous self confidence gained in this project by the Navy's weapon planners, the naval architects and the shipbuilder laid the foundation for the more audaciously designed warships that later emerged from Indian shipyards."

The Russian Acquisition **:** Throughout the fifties and early sixties, the Soviets had kept up a steady pressure on Indian leaders, offering the armed forces anything and everything they wished to buy. The Indian Navy had resisted this pressure with the argument that all its ships were of British origin, its depots full of British spares, its manpower British-trained and its dockyards equipped to refit British ships. However, with the American 'tilt' towards Pakistan, right from fifties & Britain's refusal to supply warships, particularly submarines to India, in the early sixties, there were no further excuses left to refuse Soviet equipment. On September 1, 1965, the first of the many historic documents was signed in the Soviet Union. The Indian Navy received four Foxtrot class submarines, five Petya class patrol vessels, two Polish landing ships and five patrol boats. DNC was the nodal agency for Russian acquisitions in NHQ; & though it was hived-off to the newly constituted Directorate of Acquisition Projects (DAP), in 1968, the two continued to work in close co-operation, in the best interests of the Navy.

The Indian designers, & operators - used to British technology, had the impression that the Russians were clueless in the art of warship building. However, the Soviet ships came as a pleasant surprise. In many respects, the Soviet technology was ahead of the British. They were miles ahead of the West in missile technology. In ship propulsion too, they had advanced considerably, both in diesel propulsion and gas turbines. They had fitted gas turbines in their ships long before these made their appearance in Western ships. They had good radar, sonar and 'Electronic Warfare' equipment. If any thing,

Shri Paramanandhan and senior naval officers in Kremlin

they were poor in habitability for Indian conditions. It was however, only after the 1971 war with Pakistan, in which the Russian Osa-class missile boats, which helped the Navy score a resounding naval victory over Pakistan, that the scale got conclusively tilted in favour of Russian acquisition. A comprehensive 'list' of requirements was sent to the Russian side, which, amongst ships & submarines, also included setting up a *Design Organization* in India.

In 1973 a team of Soviet warship designers visited India to suggest an organization that could design, de-novo, frigates & submarines. They quantified the requirement to be of the order of 170 specialists for the ab-initio design of a new frigate & likewise, another 170 odd specialists for the ab-initio design of a new submarine. This magnitude of manpower was obviously inconceivable then; it is still not available! The Indian Naval Designers however, have been able to produce, not only new frigates, & new submarines, but many other new designs too. Many reasons can be given for this… & have been given; but the bottom line is the 'designer'! The Constructor is the only officer, in the Indian Navy, as in any other navy, who has to undergo, in the words of Mr. DK Brown, quoted earlier,

At the War Memorial…

'***a ruthless selection process, for the profession*** '… starting with 'academic brilliance', the post-graduate qualification & extensive 'hands-on' training. The training that the Indian Naval Constructors received at UK was described as "very severe & exacting – but not beyond the capacity of a man of sufficient intellectual caliber, who is properly prepared for it & is prepared to work hard". It is the people with right background therefore, that matters, not only the 'numbers'!

The Russian acquisition, in the beginning, did remain confined to pure 'acquisition' of Soviet ships & submarines, from 1974 onwards however, in addition to the vessels, there was increasing interaction concerning installation of Russian weapons & systems in Indian built hulls, interfaced with the western & indigenous equipment. In fact, even before the Russian missiles proved their effectiveness in the 1971 war, the Navy had expressed the desire to fit the system on board an ageing Indian ship on an experimental basis. The Soviet side had also agreed to depute a group of Russian specialists to study the feasibility of fitting missiles in existing Indian ships. However, they were not particularly enthusiastic about such a proposal. It was, therefore, decided that this job would also be undertaken in-house. *INS Talwar*, the British built frigate that was the 'fastest' available, was selected to be the first ship fitted with the Soviet missiles. A complete missile system, together-with fire control mechanism, was removed from a non-operational missile boat, & installed on-board *Talwar* during her Long Refit, (from December 1974 to November 1975). Since the width of Talwar's fox'le did not permit the siting of four missile launchers abreast, it was decided to fit only three abreast.

Present DGND in Russia

This was a very bold step – something that only a person like Shri Paramanandhan could take. He had tremendous engineering commonsense, & with the faith that he had in his people, he could take terrific risks! There were inherent uncertainties involved in such

a decision, concerning the effect on the flight paths of the missiles, required clearances between them, 'interfacing' them with the rest of the equipment, etc. In the absence of clear-cut documentation and data, quite a large amount of study had to be carried out, of the existing fittings in the missile boats in order to decide what equipment was to be removed in addition to the missile containers themselves, what was the interface, how the fire control would work and so on.

The modification work completed, the first missile firing was carried out on 11 December 1975. It scored a bull's eye on a target moored at a range of 20 miles. Other two followed suit. This gave the Directorate of Naval Designs, substantial confidence in taking up future warship designs with a 'hybrid' package of Western & Russian weapons. The 'Russia-connection' changed the very ethos and the structure of the Indian Navy!

On the 'lighter' side, all the earlier acquisitions from Russia had to be re-painted to light gray; for, that was then the colour of IN ships. There were incessant complaints about colour fades etc that could never be resolved. Cdr. Deans, then the Assistant Manager Industrial (Construction) at ND (B) proposed that the IN should discontinue the British practice and standardize on the Russian 'dark gray'. There was a Fleet review due in Mumbai. The proposal was accepted 'over night' and the 'change' implemented for the entire fleet within the next 6 weeks. Even the Indian warships had taken the Soviet colour!

Inauguration of South Dry dock at ND(V) as per Soviet Project Report

The Directorate of Naval Designs **:** Till 1969 when the case was taken up for creation of an independent Directorate of Naval Designs, the Corps strength was a mere 30, which included 8 officers who were still under training then. It was envisaged that it might be possible

to induct a few warship designers from Britain, on loan, to design the 'follow on' frigates. However, that could not be done. As a result when DND was formed, in 1970, it had only a handful of Constructors, with 'key' designers already away, to the Directorate of Leander Project (DLP), which had been formed a year earlier. It therefore 'took off' on a rather low-key, designing 'higher versions' of the ships that had been designed earlier under DNC; Landing crafts, survey vessels, seaward-defence boats (*SDB's*), etc. However, in naval architectural terms, this turned out to be as challenging a job, if not more, as the 'follow-on' Leanders, that were also undertaken subsequently, as Project 16.

The *SDB Mark-I* had a max. speed of 15 knots where as the Staff requirement for *Mark-II* was : a sprint speed of 30 knots, with in the same sized hull (37.5 m long). This called for a totally new design, which *was* undertaken & the 'model test' successfully carried out at UK, in 1972. For any new ship design, a 'model test' is mandatory. The only 'model-testing-tanks' available in India, till 1990, were, one at IIT Kharagpur, for training of Naval Architecture students & the other at the Central Water & Power Research Station (CWPRS), Pune, which was used by the Army, mostly for civil engineering projects. Both were not suitable for tank-testing of warship models.

It took another Constructor officer, Cmde. Mukherjee, to get the sanction for the prestigious hydrodynamic test facility, the "high speed towing tank" (HSTT), at the Naval Ship Research Laboratory (NSTL), Visakhapatnam! The HSTT was commissioned in 1990 & has undertaken extensive repeat hydrodynamic model testing to build up indigenous capability, under the Constructor officers, since then.

Keel laying for modified SDB

YEAR	SHIP	JOB UNDERTAKEN BY HSTT (NSTL)
1990	SSK Submarine	Calibration of speed log in HSTT
1992	SSK Submarine	Calibration of speed log in HSTT
1992	LCU	All standard model tests including • Resistance • Paint flow • Wake survey • Self propulsion and open work
1994	SSK Submarine	All static and dynamic tests using Vertical Planar Motion Mechanism (VPMM)
1994-95	1241RE Missile Boat	All standard model tests
1995-96	P-17 Frigate	All standard model tests, Seakeeping tests in head seas
1996, 2001	Submerged Pontoons and Buoys	Drag, Manoeuvring and Mooring studies
1996-97	P-20 Survey Vessel	All Standard model tests
1997	Rajput Class (61 ME)	All Standard model tests
1997-98	P-15 Frigate	All Standard model tests Seakeeping tests in head seas
1998	P-25 Corvette	All Standard model tests
1998	1234E SNR	All Standard model tests
1999	877EKM Submarine	All VPMM tests including Powering performance Manoeuvring Control surface effectiveness

2000	266ME SNM	All Standard model tests
2000	1258E	All Standard model tests
1999-2000	New Design Submarine	All VPMM tests including Powering performance Manoeuvring Control surface effectiveness
2001	Sandhayak	Calibration of Smart Acoustic Current Meters
2002, 2006	ADS	All standard model tests Captive Manoeuvring tests using Large Amplitude Horizontal Planar Motion Mechanism (LAHPMM)
2002-03	P-15A	Performance Evaluation of Hull mounted and Bow mounted Sonar domes Cavitation inception tests on Bow mounted Sonar dome CFD analysis of flow around Bow mounted dome
2003-04	P-28 ASW Corvette	All standard model tests Evaluation of Bow mounted Sonar domes – 2 versions Cavitation inception tests on Sonar dome CFD analysis of flow around Bow mounted Sonar dome
2005	SUT Torpedo	Testing and analysis of Composite Propellers for Cavitation and acoustic performance
2006	P-15 Ship	Design and development of Modified Propellers and Validation by sea trials

On the whole, as the first design from the DND, the *SDB Mark-II* was a very 'professional' & satisfactory project. It was subsequently built into four more versions, *Mark-III*, with a different propulsion machinery & therefore a little longer; Torpedo Recovery Vessel; Survey craft; & the Customs vessel for the Coast Guard. In all, 5 *SDB's Mark-II*, 6 *SDB's Mark-III*, 4 Survey crafts & 2 Torpedo Recovery vessels were built for the Navy, at GRSE & GSL. In addition, a number of ships were delivered to the Coast Guard.

The other important designs that came out of DND during this period, were :

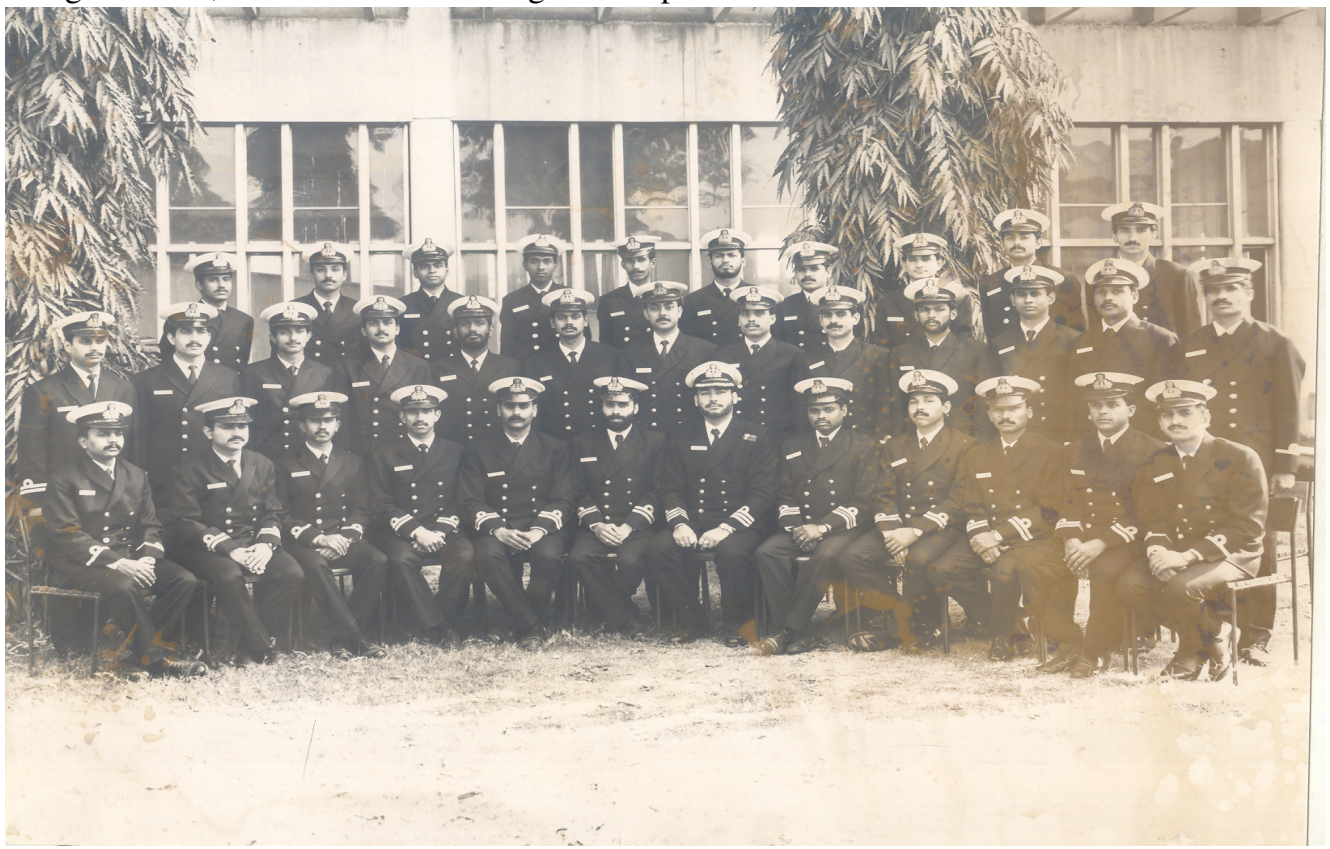
- ✓ Landing Craft Utility – Total 9 ships delivered between 1978 & 1987.
- ✓ Landing Ship Tank (Large) – That was the largest ship (at that time), to be designed (& built) indigenously & had the lowest wading depth for its size, (1.1 m.). The construction was delayed due to various reasons & the ships delivered in 1987 (Magar), & 1997 (Gharial).
- ✓ Survey Ships – Improved *Darshak* design called 'Sandhayak' class, (*Sandhayak*, *Nirdeshak*, *Nirupak*); The improved *Sandhayk* design called the 'Investigator' class, (*Investigator*, *Jamuna*, *Sutlej*); & the improved *Investigator* design called the 'New Darshak' class, (*Darshak*, *Sarvekshak*).
- ✓ Ocean Going Tug – which also got delayed. Though the order was placed on GRSE in 1973, the ship (*Matanga*) was commissioned only in 1983.

Prof RC Malhotra and other IIT Faculty with COM, DNA and NCW Staff

Entry & Training of NC officers **:** As rightly envisaged by Admiral Daya Shankar, getting the Naval Architects to join the Navy, did turn out to be difficult, & in fact, continues to be so, if not more, even now! During the initial years the 'toppers' out of the ME cadets were sent to UK for 'conversion' to

Constructors. This has been the most successful scheme so far, but could not be continued, as the DME was not happy to 'loose' his officers, particularly the 'bright' ones. Also, the Govt. was not very keen to spend foreign exchange for their 'longish' training in UK, which consisted of a two-year 'basic training', followed by about 'one & a half' year course leading to PG degree. However, the professional requirements of a Constructor being ***ruthless***, DNC was not willing to compromise on the QR's, i.e.

- ✓ Brilliant academic background, particularly in mathematics & physics;
- ✓ Post-graduate qualification in Naval Architecture; &
- ✓ Practical experience in warship design & construction/repairs.



NCW Batch of Constructor officers - 1987 & 1988

When IIT Kharagpur started producing Naval Architects, it came as a big relief to every one, particularly after a few of them, from the earlier batches, did join the Navy. The recruitment became 'part cadet entry, part direct entry'. By 1967 the Navy had a few UK trained Constructor officers & it was felt that these officers could provide the basic training to the IIT Naval Architects, in India itself, who can there-after proceed to UK, for the PG course only & therefore a

much shorter duration of 1.5 years. This was approved by the Govt. The IIT also agreed to allow a Naval 'training cell', to be set up with-in the Department of Naval Architecture & Marine Engineering for the purpose. Thus in 1967 the 'Naval Construction Wing' (*NCW*) was established, at IIT Kharagpur with Cmde. Mukherjee as the first 'Officer-in-Charge'; he was then Lt. Cdr. appointed as Cdr. (While holding appointment), for the prestigious job!

It soon became clear however, that the IIT Naval Architects were not interested in joining the Navy; only ten of them had joined till 1971, & hardly anyone thereafter. All these officers completed their PG course from UK. Thereafter, a change became necessary on account of Russian acquisitions. In 1972 the first batch of officers was deputed to USSR for training. The number of officers attending the UK training was reduced & subsequently, more or less, discontinued altogether.

NCW Batch of Constructor Officers - 2005 & 2006

PG Training : 1967 - 1976			
Year of commission	Total Officers Joining the Corps	Officers trained In UK	Officers trained In USSR
1967	4	4	----
1968	2	2	----
1969	2	2	----
1970	1	1	----
1971	1	1	----
1972	3	----	2
1973	5	1	3
1974	12	2	2
1975	9	1	----
1976	4	0	1
Total in 10 years	**43**	**14**	**8**
Total Corps Strength (in 20 years)	**65**	**36**	**8**

The Third Decade : 1977 - 1986

Despite the 'man-power' problems, the Corps was innovating & evolving. The big batch of 12 officers in 1974 was possible by depriving DME once again of some of the Engineering cadets. Entry to the corps had been 'opened' to graduate engineers from regional engineering colleges as well; in Mechanical, Civil & Metallurgical disciplines. Kharagpur being a remote place, the under-training officers were not getting enough opportunity of interacting with the designers on 'live' projects; the NCW therefore was shifted from IIT Kharagpur to IIT Delhi. This had its own repercussion, as there was no water-tank or model-testing facility at IIT Delhi. In order to compensate for the reduced 'hands-on' training, therefore, a Constructors' Training Office (*CTO*) was created as part of INS Satavahana at Visakhapatnam in 1976, with Cdr. Arora as the Officer-in-Charge.

The CTO provided a six-month's 'warship design orientation' training to the fresh engineering graduates, after their 'Basic-&-Divisional' course. With-in a year of its formation, the CTO was shifted inside the Naval Dockyard Visakhapatnam. In 1981 the Shipwright School was also shifted from Bombay to Visakhapatnam & in 1986 CTO became a part of the Shipwright School. It was envisaged that in not too distant a future, the Navy will have a full fledged 'Hull' training establishment for officers & sailors, similar to INS Shivaji in 'Marine Engineering' & INS Valsura, in 'Electrical Engineering' disciplines.

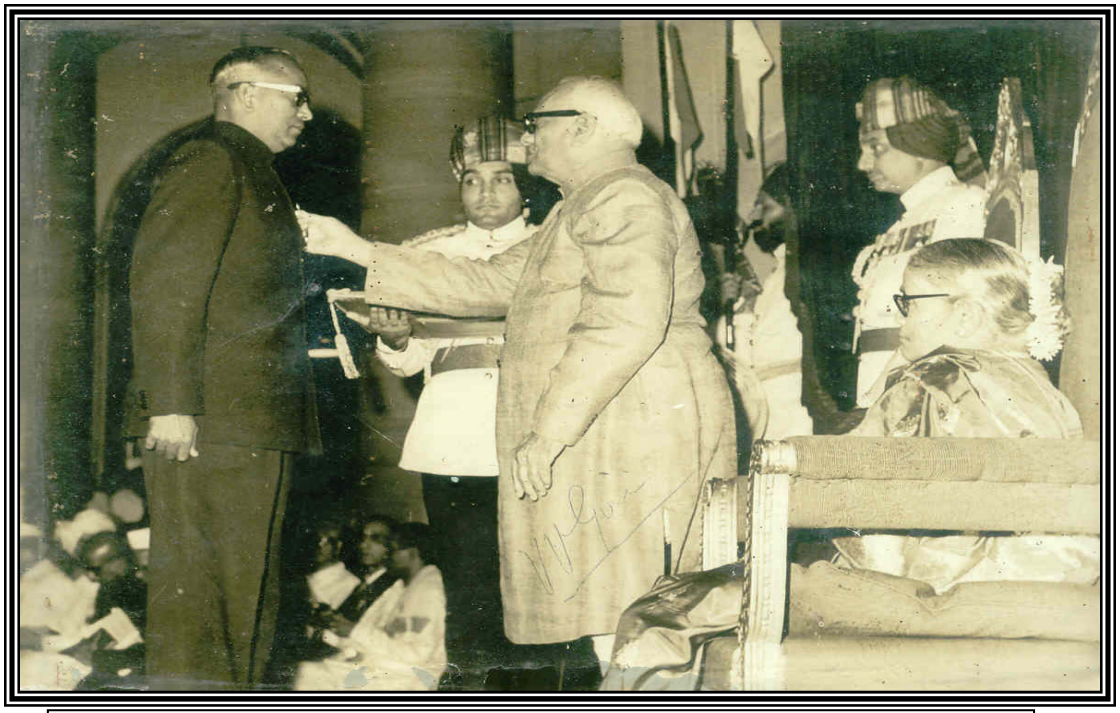
In the early eighties, Naval Architects were being produced by IIT Madras & Cochin University also, although hardly any was inclined to join the Navy. All concerned had acknowledged the 'quantitative' shortages in the cadre; not many were really concerned about the 'qualitative' requirements, other than the DNC. Soon, with the demise of the erstwhile USSR, PG courses in that country were also discontinued. Instead, the officers began to be deputed to various Indian Institutes of Technology for M. Tech. in miscellaneous disciplines like Ocean Engineering, Corrosion Engineering, Metallurgical

Inauguration of Paint shop in ND(V)

Engineering and Rubber Technology, etc. While this broadened the subject coverage at PG level within the Corps, the core competency of Warship/ Submarine design, which was being taught in courses at UK and erstwhile USSR, was gradually eroded.

All this notwithstanding however, a lot was happening on the professional front. In the words of Admiral Hiranandani, (from his book 'Transition to Triumph') :

"Throughout the decade 1965 to 1975, the non availability of sanctioned manpower constrained the balanced growth of the Design Organization. The shortage of service officers was particularly acute. In retrospect, the successful achievements in warship design during this period can be attributed to two factors:



Shri S Paramanandhan, Director of Naval Design, receiving the PADMASHRI award from Dr. VV Giri, the President of India

(a) Accepting an overlap between the "design" and "production" phases. This enabled a shorter time frame from the concept design stage to the completion of the first ship of the class. It minimized the obsolescence factor. And it ensured lower costs by minimizing escalation.

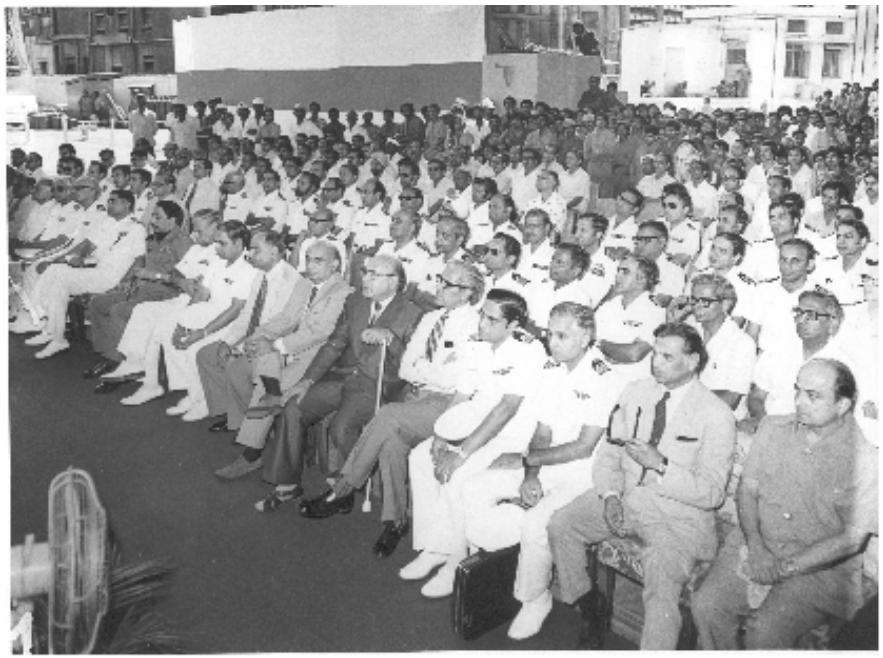
(b) The team of talented young constructors built up over the preceding twelve years by the founding fathers of the Design Organization, which included Shri S. Parmanandan, Shri Dotiwalla, Shri Dhumal, Commodore V P Garg, Captain Thukral and Captain KK Lohana.

Shri Parmanandan was awarded the *PADMASHRI* in 1970 in recognition of his eminence as the leading naval architect in the

country and his dynamism, dedication and drive in building up the capability of his organization".

Project 16 : Godavari Class Frigates **:** Project 16 was the designation given to the three frigates that followed the six ships of the Leander Project . The staff requirements for this new design incorporated the lessons learnt in the recently concluded 1971 Indo-Pakistan War. Apart from upgrading the package, they called for augmentation and a mixed origin of weapons, which included surface & air capabilities, in addition to the anti-submarine capability of the earlier frigates. The ships were required to carry two nos. *Seaking* helicopters, so that at any one time, one of the two could be kept in the air, for either an anti submarine mission, or anti ship mission. As it was not possible to meet either of these requirements in the existing platform, the project was passed-on from DLP to DND for developing a new design.

The work on Project 16 commenced in 1974, by Capt. Mohan Ram (then Cdr.), & Capt. Subbiah (then Lt. Cdr.); & the preliminary design was completed by 1975. The earlier ships were propelled by steam turbines; Navy wanted the new class to be fitted with gas turbines, & higher speed, from 28 knots to at-least 29 knots. However, this proposal was rejected on the grounds of economics since the country had made substantial investment in the indigenous development of steam machinery. Besides, this would have put unduly high pressure on the design team! It was therefore agreed to retain the same power plant for the new ships. The consequent 'reduction' in the maximum speed of the ship, which was expected, was accepted. However, during the detailed design phase, which commenced in 1976, it was realized that the new ships would be about 12 to 13 meters longer & 'thinner' as compared to the earlier design. Capt. Mohan Ram predicted that there would therefore be no 'loss' of max speed; in fact the ship will go 'faster'! This was confirmed in the subsequent model test & the full-scale trials. The designers had hit upon the 'right' hull-form that resulted in a 'lower' wave-making resistance, & there-by the total resistance of the ships, at higher speeds; at lower speeds however, the fuel consumption was slightly higher, due to higher frictional resistance



Inauguration of construction of 1st Godavari Class Frigate (02 Jun '78)

of the new design. The new ships therefore, had bigger fuel tanks!

Godavari's keel was laid in 1977. MDL wanted the Navy to depute an officer to help the shipyard in 'translating' the Navy's design into workshop drawings. Capt Lohana was deputed for the job as Cdr. He was promoted while on deputation. In 1980, on completion of NHQ work & in keeping with the policy of assigning the designers of a ship to the task of building the ship, Capt. Subbiah was posted to the Warship Production Superintendent organization in Bombay. By 1983 he had accomplished his mission of 'completing' the first ship of Project 16. The other two ships *Ganga* & *Gomti* were commissioned in 1985 & 1989 respectively.

"Enormous synergy was generated by the interchange of talented young naval architects between ship design assignments in the Directorate General of Naval Design and assignments as naval overseers in the warship building yards to oversee the construction of the ships that they had helped to design. This synergy helped Mazagon Docks, Garden Reach and Goa Shipyard to acquire the confidence in the 'hybridising' that was to become standard practice in Indian naval warship building", says Admiral Hiranandani in his book, 'Transition to Eminence'.

<u>*Vizag Dockyard*</u> **:** The 'new' dockyard at Visakhapatnam, *ND*(*V*), had grown out of the erstwhile Base Repair Organization, *BRO*, to become one of the most modern dockyards in Asia, with the largest dry-dock, which was taken over by the Navy from Army engineers in 1978. Constructors played a key role during the design & construction phases of the dry docks, as also the other workshop facilities for the Fabrication & Outfitting activities at ND(V). Bold initiatives were also taken for indigenous development of the superior Soviet steels & the electrodes for repairing Russian ships & submarines.

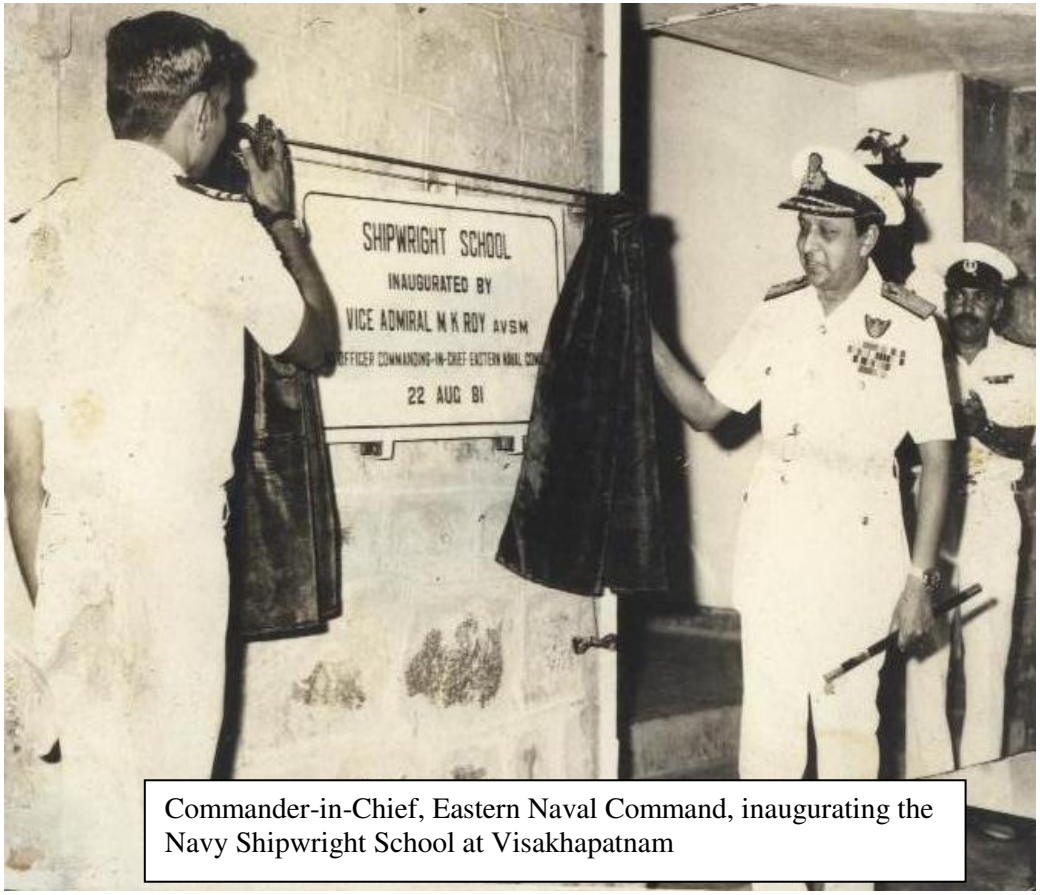
Admiral Inamdar, ASD(V) handing over to Cmde Misra on 27 Sep 1982

Unlike Bombay, the tide variations at Vizag are

minimal; there were therefore, no restrictions on the docking & undocking activities on this account. This gave great freedom to the docking officers to exploit the facility to max extent. Multiple dockings became a matter of routine! The dry-dock Caisson was found to have stability problem, which was rectified by adding 250 tones of ballast. There was siltation at the dock-gate that led to problems in operation of the flap-gate. There were problems in the pump-house as well. All this experience was used in laying down the QR's for the new 'covered' dock, which was commissioned in the next decade.

The decade from 1977 to 1986, therefore, was the period of '***Transition***' for the Corps. On one hand, the 'Design' had evolved from Leander Project to Project 16; on the other hand, a lot of innovation was going on in the newly established ND(V). The "medium refit" of Landing Ship tank (*Gharial* & *Guldar*), was completed without any repair documentation. It was followed by the medium-refit of *Petya* class ships (*Kamorta* & *Kadmatt*). The Soviet specialists who came to 'help' were more of a 'hindrance'! They were aghast to see such extensive corrosion & renewals. Viewed from this angle, the 'medium refit' of the submarine, *Khanderi*, was a far better experience.

The Navy's Shipwright School had grown into a highly professional body & the DNC, who was now the DNA, was very keen to get the same commissioned as a naval Training establishment, INS "Vishwakarma"! The name was recommended by a 'Board' of officers, but remained confined to paper only – where it remains still buried.



Commander-in-Chief, Eastern Naval Command, inaugurating the Navy Shipwright School at Visakhapatnam

The Fourth Decade : 1987 - 1996

Shri Paramanandhan remained the only DND, from 1970 to 1976. From 1976 onwards he continued in the upgraded chair of DGND. Capt. Lohana, who had already taken permanent absorption at MDL by then, was invited to take over as DGND, on reverse deputation, as the post was upgraded to "RAdm. Or Civilian Equivalent". Shri Paramanandhan stayed with the Navy for another year as a Consultant, to set up a "Design Bureau" before bidding final farewell; the Corps however, still continues to regard him as the 'father figure'.

After retirement from Navy, Shri Paramanandhan joined the Cochin University of Science & Technology, (*CUSAT*), & served as the 'Head', Ship Technology Department, CUSAT, from 1984 to 1989. During this period another 'mini' Naval Construction Wing was started at Cochin, for training the Naval Architecture cadets at CUSAT, under the 10+2 scheme.

The decade, 1987 to 1996, was the period of ***Evolution*** for the Corps!

CUSAT remains to-date, the major provider of human resource to the Corps of Naval Constructors in the Indian Navy.

Naval Construction Wing **:** The NCW at IIT Delhi had grown on the lines of RCNC training establishments in UK; it was a combination of the 'culture' of the Royal Engineering College Greenwich, with the 'atmosphere' of University College London. With the help of Prof. RC Malhotra, the then 'Head' of the Applied Mechanics Department, who was instrumental in 'shifting' of NCW from Kharagpur to Delhi, the Faculty at the

Dept. & other IIT officials, NCW was given respectable accommodation, for the office space, as well as, the hostel. The under-training Constructor officers soon distinguished themselves in various extracurricular activities of IIT Delhi. Constructors have always made special contributions in promoting cultural activities, in the Navy, as well as outside it!

NCW soon became the National 'hub' of the professional activities in naval architecture. The 'Delhi Chapter' of the Institution of Naval Architects (*INA*) was started in 1986, with the DNA as the 'Chairman', by designation; OI/C NCW as the 'Secretary', & an NCW officer as the 'Treasurer'. This proved to be a winning combination, producing excellent results over the years – the latest being the production of "Journal of Ship Technology", *JST*, in 2004, which is the only Indian journal of Naval Architecture in the country that meets the international standards of technical journals.

An important activity of INA (Delhi Chapter) is the "Commodore Garg Memorial Lecture", *CGML*, in the honour of late Cmde. Garg, the first uniformed Naval Architect in India. This is a one-day event that includes a lecture by an eminent professional, followed by a cultural programme. So far it remains the only regular (annual), professional event for practicing Naval Architects, at the national level.

'Pot Shilpkar Geet' during the Commodore Garg Memorial Lecture

The first CGML was delivered by Admiral Whig, then Cmde. & the DNA, on the 19th March 1988. Since then a number of prominent Indians have spoken from the CGML platform, including Capt. Mohan Ram. And, it is not just coincidence that he has been the guest speaker, twice in twenty years!

Various CGML Pictures

(Late) Mrs Ursula Garg being felicitated by Oi/C NCW

Mrs Soona Dotiwala presenting Sam Dotiwala

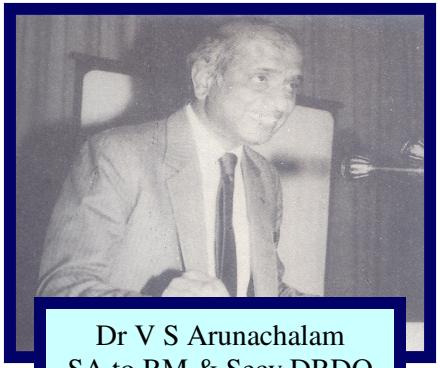
Mrs Subhash Thukral presenting Cmde Thukral award

Distinguished guests during the lecture

Cmde R K Whig AVSM, VSM
(1988)

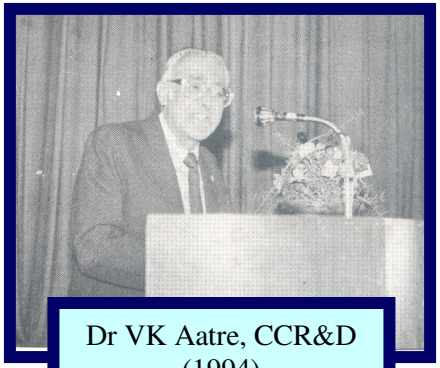
Capt N S Mohan Ram VSM (Retd)
GM, Mukund Iron and Steel
(1989)

VAdm K K Nayyar PVSM, AVSM (Retd.)
(1990)

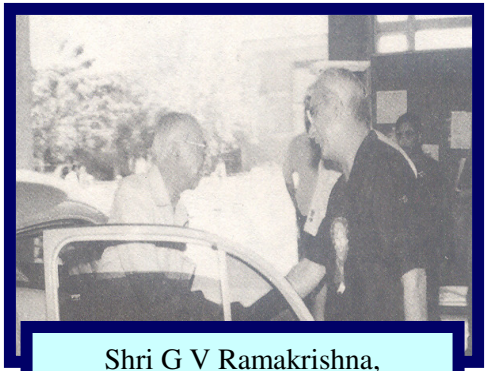


Dr V S Arunachalam
SA to RM & Secy DRDO
(1991)

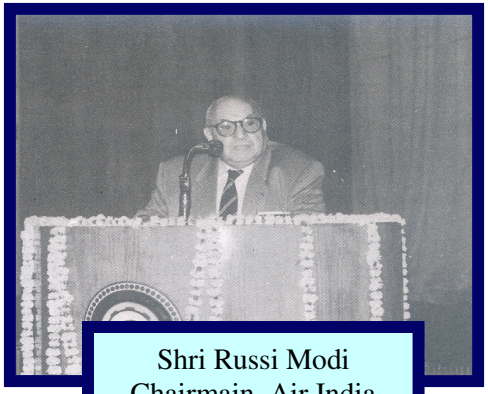
Dr P Rama Rao,
Secretary, Dept of Science & Technology
(1992)



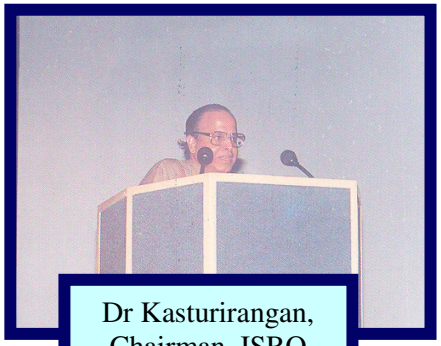
Dr VK Aatre, CCR&D
(1994)



Shri G V Ramakrishna,
Member, Planning Commission
(1995)



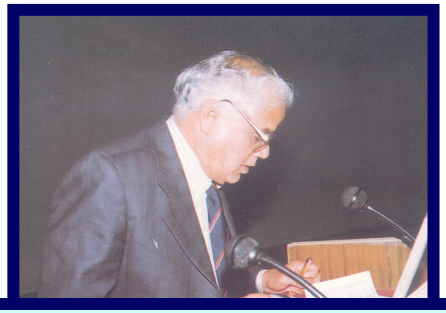
Shri Russi Modi
Chairmain, Air India
(1996)



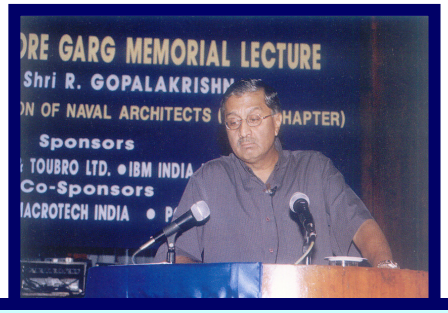
Dr Kasturirangan,
Chairman, ISRO
(1998)

VAdm I C Rao PVSM, AVSM (Retd)
(1999)

VAdm RB Suri PVSM, AVSM, VSM (Retd)
(2000)

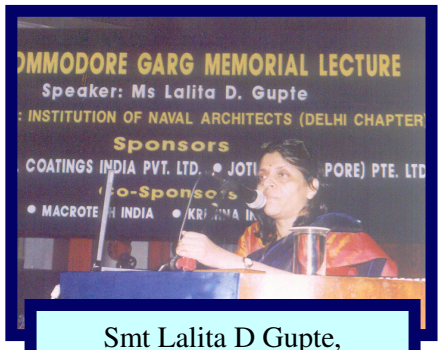


Capt N S Mohan Ram VSM (Retd) FNAE
Advisor, TVS Motor Company Ltd.
(2002)

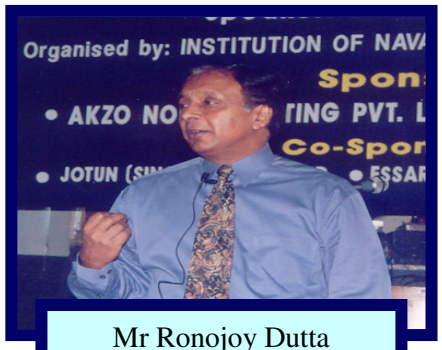


Shri R Gopalakrishnan,
Executive Director, Tata Sons Ltd
(2003)

Dr Ashok Jhunjhunwala,
Professor, IIT Chennai
(2004)



Smt Lalita D Gupte,
JMD, ICICI Bank Ltd
(2005)



Mr Ronojoy Dutta
CMD, Air Sahara
(2006)

S. No.	Date	Name of the Speaker	Topic for the Lecture
1.	09 Mar 1988	Cmde RK Whig, AVSM, VSM	Human Resource Development for Naval Architecture
2.	04 Mar 1989	Capt NS Mohan Ram, VSM (Retd.) GM Mukund Iron & Steel	Ship Acquisition in India
3.	17 Mar 1990	V Adm KK Nayyar, PVSM, AVSM (Retd)	Navy of the Nineties - Challenge in Ship Design.
4.	16 Mar 1991	Dr VS Arunachalam , SA to RM & Secy DRDO	Concurrent Engineering – The Inevitable Option
5.	03 Oct 1992	Dr P Rama Rao , Secretary, Dept of Science & Technology	Materials Design
6.	08 Jan 1994	Dr VK Atre, Chief Controller, Research & Development.	Technology Development – Experiences
7.	08 Apr 1995	Shri GV Ramakrishna Member, Planning Commission.	Economic Reforms – A Perspective
8.	16 Nov 1996	Shri Russi Modi, Chairman, Air India	Experience in Private & Public Sectors
9.	25 Apr 1998	Dr K Kasturirangan, Chairman, ISRO	Indian Space Programme – Present and Future
10.	30 Oct 1999	V Adm IC Rao, PVSM, AVSM (Retd)	Development of Coastal Transportation in India
11.	04 Nov 2001	V Adm RB Suri, PVSM, AVSM, VSM (Retd)	Emerging Scenario of the Navies in early 21st century
12.	23 Feb 2002	Capt. NS Mohan Ram VSM (Retd.) Advisor , TVS Motor Company Ltd.	New Product Development

13.	29 Mar 2003	Mr R Gopalakrishnan, Executive Director Tata Sons Ltd.	Crossing the Oceans - The Dilemmas of Leadership
14.	13 Mar 2004	Dr. Ashok Jhunjhunwala, Telecommunications Entrepreneur and Professor, IIT Chennai	Towards Doubling the Rural GDP of India
15.	05 Mar 2005	Mrs. Lalita D. Gupte, Joint Managing Director, ICICI Bank	Challenges of Change
16.	06 Apr 2006	Mr Ronojoy Dutta, President Air Sahara	Organizing for Success

In order to honour the other pioneers of the Corps, NCW introduced the following awards

Shri Paramanandhan Gold Medal, awarded to the 'topper' in NCW course, on behalf of the Chief of the Naval Staff;

Commodore Garg Silver Medal, awarded for the best 'Project' in NCW course, on behalf of the Vice Chief of the Naval Staff.

Commodore Thukral cash award & medal, given to the best technical paper presented to INA (Delhi Chapter) by a 'Student Member'.

Shri Sam Dotiwala cash award & medal, given to the best technical paper presented to INA (Delhi Chapter) by a 'member'

In addition, the Corps had a "Corps song", which the under-training officers 'sing' during the cultural programmes. This song is in Hindi, the national language, & appears as such, in this book. An English translation is given below :

The Corps Song : "We, the Naval Architects…"

*(Translation of the **"Pot-Shilpikar Geet"** from Hindi)*

That (*country*) **which has a sea** (*each*), **playing in both** (*her*) **arms,**
That (*country*) **whose feet are continually** (*being*) **washed by the Ocean,**
(*And that country*), **in whose arteries too, there is perennial flow of water only,**
(*We*) **bow a thousand times, to that country of ours, India;**
We, the Naval Architects…. We are the Naval Architects…..

The one passion (*that we have*), **is that we bind the ocean with** (*the produce of our*) **creativity,**
That adorns the (*sea*) **surface,** (*as well as*) **the deep, like bridges, movable** (*as well as*) **stationary,**
(*Pray*) **we produce such ships that earn reverence for us in the world,**
Water-transportation also swells (*with their help*), **&** (*we earn*) **glory in warfare too.**
(*For*) **we are the helmsmen of the** (ship of) **maritime prosperity of India.**
We, the Naval Architects…. We are the Naval Architects…..

Humble, yet resolute; let us promise this (*to ourselves*) **today,**
That (*from now on*) **we opt for** (*nothing but*) **the 'Excellence" only,** (*in our lives*) **at every step,**
(*That, our*) **energies** (*we*) **never** (*allow to*) **get diluted;** (*and that*) **we all** (*invest them so that we are able to*) **develop this competence in us,**
(And) **That** (*we take care of*) **the coming generations** (*who*) **too, are full of 'potential'!**
We, the Naval Architects…. We are the Naval Architects…..

पोत शिल्पकार

जिसकी दोनो बाहुओं में खेलता समुद्र है,
जिसके पग सदा पखारता महासमुद्र है,
अजस्त्र जल प्रवाह ही, है जिसकी धमनियों में भी,
उस अपने देश हिन्द को नमन हज़ार हैं,
पोत शिल्पकार हैं... हम पोत शिल्पकार . . .।

लगन है एक बाँध दें समुद्र को कृतित्व से,
जो तल अतल में चल अचल हो सेतुबन्ध सा सजे,
बनायें ऐसे पोत हम कि जग में अपना मान हो,
जल यातायात भी बढ़े और युद्ध में भी शान हो,
भारत की जल समृद्धि के हम कर्णधार हैं,
पोत शिल्पकार हैं... हम पोत शिल्पकार . . .।

विनम्र किन्तु दृढ़ प्रतिज्ञ आज हम ये प्रण करें,
कि हर चरण में श्रेष्ठता का ही सदा वरण करें,
क्षमता कभी ना व्यर्थ हो, हम सब में ये सामर्थ्य हो,
कि आने वाली पीढ़ियाँ भी होनहार हैं,
पोत शिल्पकार हैं... हम पोत शिल्पकार . . .।

रचयिता : *(कमांडर)* **कुलदीप वर्मा**
भा.नौ. (से.नि.)

Projects 25 & 25-A **:** By the time Shri Paramanandhan retired, the Corps of Constructors had reached the level of 'recognition' in the Navy. During the period that he was at the helm, Navy's Design organization produced over 15 successful designs, to which more than 75 warships of different sizes, types, & 'class', have so far been built. Project 25, Khukri Class Corvettes, was his last design project in the Navy. In fact, the Navy had been looking to 'buy' the corvettes from other countries, for quite some time, however, since none of those fitted the bill, in 1976 the work was assigned to DGND. The 'design team' under Capt. Subiah, then Cdr, developed a new hull form meeting all the Staff Requirements, which amounted to packing a much heavier weapon load than that on the Leanders, but at less than half their displacement, together-with the capability of helicopter operation from such a small platform! The design was validated through model tests at the SSPA tank in Sweden & completed in 1978 itself. However, the project got unduly delayed – first in-house, on account of delay in finalisation of the propulsion package and subsequently, due to the delay in clearance for the weapon package from the Soviet Union.

Capt Lohana briefing senior Leaders, Shri KC Pant and Shri Shivraj Patil

Orders for the first two corvettes were placed on Mazagon Docks in 1986. *Khukri*, launched in December 1986, was delivered in 1989. *Kuthar* was launched in January 1988 and delivered in 1990. Mazagon Docks then acted as the 'Lead yard' and provided all drawings and shipbuilding material inputs to Garden Reach for building the next two corvettes. *Kirpan* was delivered in 1990 and *Khanjar* in 1991. Later in the 1990s, orders were placed on Garden Reach for four more corvettes, with slightly different weapon package, under Project 25-A, called Kora-class : *Kora* (1998), *Kirch* (2001), *Kulish* (2002), & *Karmuk* (2003).

Subsequent Ship Design Projects **:** The designs of 'Cadet Training ship' *Tir* & the Fleet tanker *Aditya* had been completed during Shri Paramanandhan's time. Construction of *Tir* commenced at MDL in 1982. The ship was launched in 1983 &

commissioned in 1986. *Aditya* was built by GRSE; although the order was placed in 1985, the ship could be commissioned in 2000 only, due to various difficulties experienced by the yard.

All these designs so far, had been completed without computers! Hand-held calculators were the best that were available to the designers. They were not the Navy-supply items in any case! Although people with foresight like Cdr. Nigam had been making efforts for many years, Computers started 'trickling-in' during the late 80's only. Today the Indian Navy's Design organization is highly hi-tech; at par with the best in the world! And, with the winning combination of the best men & the best machines, the designs that followed, had to be the best too.

INS Aditya on the 10,000 T Ship-Lift at the new Naval Base at Karwar

First Indigenous 'Destroyers' (Project 15) **:** Discussions on the 'follow-on' ships to the Godavari class frigates, with enhanced anti-submarine capabilities, were going on from the early 80's. The weapon package offered by the Soviets was considerably 'bigger'. The Navy had also been wanting to introduce & standardize gas-propulsion on Indian warships. All this resulted in a much bigger platform. The Leanders are 113.5 m. long & displace 2900 T. Godavari with the length 126.5 m. & displacement 3850 T. were 20% bigger than Leanders. Project 15 design, in contrast, turned out with the ship 151.5 m. long, & displacing 6600 T. It was no longer a frigate; it turned out to be a destroyer!

The design was undertaken under the leadership of Admiral Gupta, then Cdr. Model tests were carried out at SSPA Sweden, in late 1985 & the results were found to be more than satisfactory. However, since it was the first time that the design of such size & complexity was undertaken by DGND, Capt. Lohana, he decided to carry out repeat model tests at the Krilov Institute in Soviet Union, as a cross-check. This was done in 1986, & the design verified. Order was placed on MDL for three ships under Project 15, called the *Delhi* class destroyers. Due to the breakdown of Soviet Union unfortunately, the construction got delayed. *INS Delhi* was finally commissioned in 1997; *Mysore* in 1999; & *Mumbai* in 2001.

Delhi class destroyers were the biggest warships designed till then & built in India. They were also the first ever gas turbine propelled ships designed indigenously. And they have turned out to be highly successful weapon platforms with excellent performance at sea.

Aircraft Carrier **:** INS Vikrant, a world-war vintage ship & India's sole aircraft carrier was modernized in two phases. One of the major modifications undertaken during the second phase, from 1987 to 1989, was the fitting of "ski-jump" for launching the 'sea-harrier' aircraft, in the 'short take-off' mode. Vikrant earlier had 'Alize' aircraft that had been phased out & the old fashioned steam catapult & arrester gear meant for them, had become obsolete.

The ski jump installation was a massive exercise which virtually involved redesign of the forward one third of the ship; removal of the catapult machinery & fittings, re-appropriation of a whole lot of compartments below the steam catapult, extensive structural modification of the deck, creation of new compartments under the ski jump, rendering the flight deck worthy and coating it with the new anti-skid paint developed by NCML. At the end of it all, the ski jump was to have an exit angle of 9.75 degrees, which required meticulous execution of the structural design, translating it from prefabricated modules to be placed precisely and welded without distortions to achieve the exact exit angle, with-in the specified 'tolerance' of 54 minutes of arc. The Fabrication Dept. under the Manager, Cdr. Raju Sebastian, rose up to the challenge & completed the entire work in record time. The exit angle had been achieved with the accuracy of plus minus 10 minutes of arc, far below the specified minimum. Cdr. Sebastian was

INS Vikrant entering CG Dock

awarded the Vishisht Seva Medal for this achievement, in 1990.

Indigenous Aircraft Carrier **:** The Navy had been examining various options of a replacement ship for Vikrant, right from the early 80's. A short 'history' given below, would throw some light on the work done by DND (SSG) on this project.

Artist's impression of the Indigenous Aircraft Carrier (IAC)

- ✓ In 1979-80, DND (SSG) had prepared a concept-design of a 'Helicopter Carrier' based on the hull form of MV Harshavardhan. This was revived in 1985, when a concept design was developed for a Sea Control Ship (SCS) with Short Take – Off and Vertical Landing (V/STOL) capability on a hull about 20,000T .

- ✓ In 1987, however, based on the revised Staff Requirements for a CTOL Carrier, capable of operating conventional long range aircraft. A concept study was undertaken with M/s. **DCN**, France, for a Sea Control Ship (SCS) capable of operating aircraft upto 18-20 tons all up weight category (F-18). The DCN report covering concept design of two flight deck variants, i.e. one with ski jump launch and other with conventional catapult as well as report on infrastructure augmentation at M/s. Cochin Shipyard Ltd. (CSL), to take on construction of SCS, was received in 1989-90. However, the design could not be pursued further due to the financial constraints prevailing at that time.

- ✓ In pursuance of the replacement philosophy for the ageing Carriers the Naval Staff proposed as an alternative an outline staff requirement for a more affordable Harrier Carrier. A concept

design was undertaken in-house for development of a Harrier Carrier design of 16500 T.

- ✓ However, the Naval Staff's further proposal to accommodate the indigenous LCA led to the development of another in-house concept design of a STOBAR Carrier at 19500 tones in 1993.

- ✓ This design had to be further modified to a new variant to accommodate an increased take off runway length for the LCA leading to an increased ship's displacement at 24000 tones for the STOBAR Carrier in 1998.

- ✓ The first Govt. sanction for the Air Defence Ship was accorded in 1999 based on the 19500 tones ship configuration whilst the design was being progressed for the 24000 tones variant.

- ✓ During this time it was felt that it may not be prudent to develop the new design exclusively for operating only one type of aircraft. Accordingly, it was decided that the carrier should also be MIG 29K capable. The flight deck size increased to around 255 meters to accommodate the take-off runway length of around 200 meters for the MIG 29 K.

- ✓ The hull form was developed and the ship's deep displacement finalized at 37500 tonnes. The model tests for the in-house developed hull form were undertaken during 2000-2001. The evolved size of the ship at around 250 meters length and about 58 meters maximum width was based on the limiting dimension of the platform that can be accommodated in

Admiral Misra as leader of the ND(V) Team responsible for the first Medium refit of submarines in India (INS Khanderi)

dry docks of Cochin Shipyard.

- ✓ During the concept design of the MIG 29K variant (37500 tones displacement) feasibility study of operating Sue-33 aircraft was also undertaken, and it was concluded that the inescapable platform size would be larger than the MIG 29 K variant and can not be accommodated for built at CSL.

- ✓ The Govt. sanction for the MIG capable STOBAR carrier has been received in Dec 2000 & the project is at an advanced stage; (Project 71).

The Submarine **:** The Navy was 'smart' to have its own submarines & the Submarine Arm, within twenty years of its birth, thanks to the Russian connection. For well over ten years thereafter, the contribution of the Constructors remained confined only to repairing the conventional double-hull Soviet submarines, although the Navy had been 'thinking' about indigenous submarine construction right from the 60's. Induction of the first submarine-submarine-killer (SSK) class submarines, designed & built in Germany, specifically to meet the Staff Requirements of the Indian Navy in the early 80's, marked the beginning of 'acquisition' of the know-how & the know-why of submarine design & construction technology in India. In October 1982, the first group of core design specialists, including the Structures-specialist, Hydrodynamics-specialist, Detailed design (Hull) specialist & model-makers, was deputed to undergo training from M/s. Ikat Leubeck (IKL), at Leubeck, West Germany. The engineering & electrical design specialists joined up six months later.

The Indian Navy Submarine Design Team (INSDT), while located at Leubeck, had frequent interaction with M/s Howa-Deutsch Werke (HDW), at Kiel, where two in number Type-1500 SSK submarines were under construction, as per the contract. Under the same contract, signed on 11 December 1981, HDW was required to transfer technology & material package to MDL for building two more submarines in India, with the provision

Inclining experiment being carried out after the Medium Refit of INS Vela

that the Indian side had the option to order, with-in the specified time frame, an additional material packages for construction of a further two submarines at no extra cost. As regards the transfer of design technology, it was agreed between the IKL & the Navy, that the same shall be achieved in two distinct phases :

- ✓ By a combination of formal lectures & discussions with IKL experts; IKL would give INSDT, complete details of the design of the type 1500 submarine.

- ✓ To check that the INSDT has fully absorbed the complexities of submarine design, it would, under the guidance & supervision of IKL's experts, develop de-novo a new design, called "Project - X", the Staff Requirements for which, were to be given subsequently, by the Navy.

INSDT was back in India by end 1984, functioning as Submarine Design Team (SDT), under DGND. In May, 1986 it was given the name, Submarine Design Group (SDG). Admiral Chaudhry was the first DND (SDG), who laid the foundation, as Captain. Cmde. Verma, who took over next, gave the SDG, shape & direction. These two Constructors are responsible for placing submarine design in India on solid professional foundation. Cmde Bhatia may be credited for having done the same from the construction & construction-supervision angle. While carrying out a stability check during the final fitting out stage of the SSK submarines in Germany, as the Overseer, he discovered that under normal operating conditions it would have an excessive trim and would not meet the criteria of reserve of buoyancy and under-water stability laid down in the specifications. According to the contract the submarines could be totally rejected and the entire project could be delayed by 6/7 years. Cmde Bhatia, then a Cdr, made special efforts along with the IKL designers in locating a pressure-proof foam that would retain its properties under repeated loading. This foam was filled into the submarine's free flooding space in the fixed hydroplanes and casing, which provided

First Medium Refit of EKM Class submarine at ND(V)

requisite buoyancy, & the submarine was accepted.

M/S HDW had designed and installed automated pressure hull fabrication stations for construction of the Indian submarines; these were the biggest submarines constructed by them till then. The fabrication process and welding protocols had been tested and approved by Quality Control Organization of German Ministry of Defense (BWB).

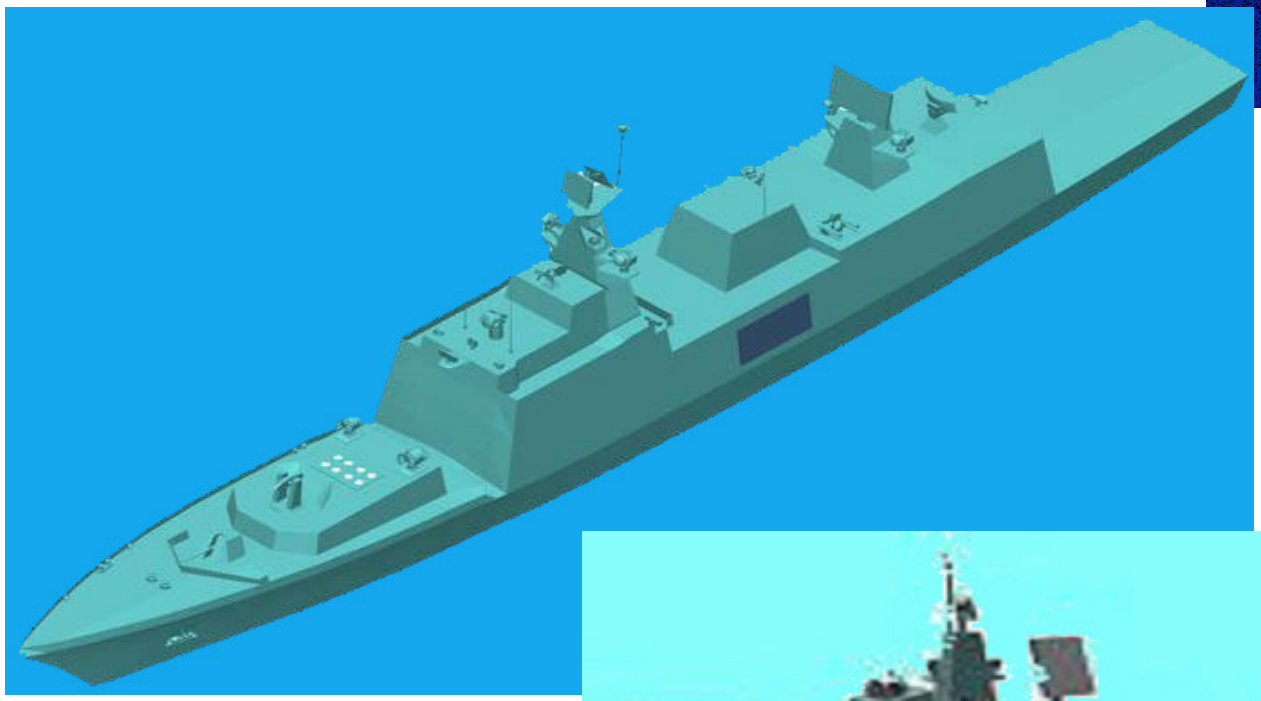
When the first hull sections came in for acceptance by the Indian Overseeing Team, nearly half of the pressure hull had been fabricated and major pressure hull welding completed. The Overseeing Team found cracks on frame/shell plating joints. However, a very close examination revealed that the cracks were transverse in nature instead of longitudinal, as is normal in high tensile steel welding, called 'hydrogen cracking'. M/s HDW supported by BWB insisted upon the sections being accepted. While the discussions for acceptance of the sections were in progress, the Overseeing Team suggested some changes in the welding procedure, which produced welding without transverse cracks. The new welding protocols were used for further welding.

M/S HDW obtained advice from number of sources e.g. the experts, University Professors, etc. however none of them could give satisfactory answers to the questions/apprehensions raised by the Overseeing Team. The discussions lasted almost 10 months. Finally a test was devised to prove who of the two was 'right'. The test confirmed the apprehensions of the Overseeing Team and M/S HDW had to accept rejecting all the sections of the first submarine welded by the initial procedure!

Later, as DNA, Cmde Bhatia was also responsible for introducing the 'long' dockings of submarines on 'slave pontoons'. This is now a routine affair in the two Dockyards.

Laying the foundation of SSK submarine construction at MDL

The Fifth Decade : 1997 - 2006



The achievements of the Corps of Naval Constructors in its earlier four decades, can be summarized in the words of Admiral Hiranandani; in his book, 'Transition to Eminence', he says : "Viewed overall, the Navy's achievements in the field of warship design & production were amazing. In the twenty-five years between 1965 & 1990, a tiny 'ship design cell' that was designing yard craft, had blossomed into the Directorate General of Ship Design, that was designing an air-craft carrier, submarines, destroyers & numerous types of large auxiliary & minor war vessels."

Despite the 'financial crunch' in the early 90's & the disintegration of Soviet Union, the decade, from 1997 to 2006, turned out to be the period of '***Recognition***' for the Corps. *INS Delhi* was commissioned in Nov.'97 & as predicted by the 'model tests', ship's sea-keeping performance was found to be excellent. With her formidable array of weapons & sensors, the ship won international acclaim during her visit to Malaysia.

The structural design of *Delhi* also proved to be sound. The ship experienced very severe storm conditions in South China Sea, for several hours, in 1999. As analyzed later, the ship could not avoid 'heading' into the storm because of two strong systems that had developed in the vicinity. Waves as high as 25 m. broke on the helicopter/hangar deck. It was acknowledged that this was an exceptionally high sea-state that the ship faced; she withstood it without any damage to the primary structure! Admiral Gupta, then Cmde. was awarded VSM for his outstanding achievement.

Project 16-A **:** The design for the 'follow-on' ships to the Godavari class frigates, was also accepted finally, with the same propulsion package as Godavari; & of-course, an updated weapon package. It was given the designation Project-16-A, *Brahmaputra* class frigates. The order was placed on GRSE. *Brahmaputra* was commissioned in 2000; *Betwa* in 2004 & *Beas* in 2005. The indigenous content of these ships was of the order of 80% & the thrust of the design was the 'integration' of this largely

Defence minister visiting P16A ship under construction at GRSE

All PSO's CNS 28/9

→ VCNS 28/9
→ DCNS
→ COP
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Pl FAX & WNC

14-N

नरेश चन्द्र
NARESH CHANDRA

भारत का राजदूत
वाशिंगटन, डी. सी.
AMBASSADOR OF INDIA
2107 MASSACHUSETTS AVE. N.W.
WASHINGTON, D.C 20008

NA/800/INR CWPA ACNS(IN) Pl 28/9

September 25, 2000

Dear George Saheb,

The Indian Naval Ship Mysore made a very successful visit to USA to participate in the International Naval Review – 2000 at New York and Sail Boston. It provided an excellent opportunity to showcase the technology development of India and our ship building capability, as also the professionalism of the Indian Navy. The visit generated a tremendous amount of goodwill among the American public and instilled a sense of pride in the large Indian-American Community.

2. The overwhelming response of the people was evident from the large number of visitors (approx 10,000) who lined to see the ship day after day. The visit also enabled our officers and men to participate in multilateral exercises with the international fleet comprising ships from fourteen countries. I am glad to report that the INS Mysore excelled in all the exercises. The commanding Officer, officers and men of the ship acquitted themselves commendably, projecting a very professional image of our armed forces in general and the Navy in particular.

3. I would recommend that Indian Naval Ships should visit US more frequently. A visit by IN ship would greatly help in projecting the potential

नई दिल्ली के उप अध्यक्ष सचिवालय
VCNS's Sectt.
क्रम सं०/Dy No. 4681
दिनांक/Date 29/9/2000

Telephone No (202) 939-7009/7011/7018 • Fax (202) 483-3972

CWPA
SO
ACSO

DGND Sectt:
1316 /DGND
Date : 03.10.2000

2614
29/9/2000

of partnership with India. You may also wish to consider whether some ports in Latin American could be included in the itinerary.

Yours sincerely,

Sd/-
(Naresh Chandra)

Shri George Fernandes,
Minister of Defence,
Government of India,
South Block,
New Delhi-110 001.

Copy to:-

1. Shri Jaswant Singh, External Affairs Minister, Ministry of External Affairs, South Block, New Delhi-110 011.

2. Admiral Sushil Kumar, Chief of Naval Staff, Naval Headquarters, New Delhi-110 011.

(Naresh Chandra)

indigenous weapons & sensors-fit, including a 'combat action information system' (CAIS), with the platform. The integration of various indigenous equipment into the CAIS, was in itself, a major task that was undertaken in the country for the first time, as a parallel activity, with the ship design, & construction.

The 'Stealth' Concept **:** The designers now have a free hand in another critical area, "*Stealth*"! Simply put, 'stealth' is - entering the enemy's territory, without being detected. It is thus the 'property' of the platform as a whole… The 'design' has to be such, as to make it totally 'detection-free'. This has always been the upper-most consideration in the minds of the designers… but achieving this has become possible only now… with the most modern technology.

The phenomenon that reveals the identity of an object is called its *signature*. A ship has many 'signatures'… the 'pressure signature', for instance, which has to be taken care of, against the mines. The 'signatures' that are important against the 'homing' torpedoes & missiles, are : the Radar Cross-section (*RCS*), the Infra-red signature (*IR*), the Noise signature, the Extra-low-frequency emissions (*ELFE*), etc.

Signature management comprises technologies that make ships difficult to detect, track and target. Lowering one signature may raise another; therefore a systematic approach to signature management is needed where threats and capabilities are balanced in order to obtain the optimum solution. The DGND has already acquired appropriate technology in this area of specialization. It is now normal for designers, for any design analysis, to create complex 3-D models of ships using sophisticated hardware & software, analyze various signatures & incorporate changes in the design to minimize the same.

Project – 17 **:** The series of three warships, *Shivalik*, *Sahayadri* & *Satpura*, presently under construction at MDL, constitutes the first indigenously designed "Stealth ships", under Project-17. The ships are scheduled for delivery in 2008-2009, & have the following important design features:

- ✓ The first design with enhanced 'stealth' features; Reduced RCS, IR & Noise signatures.

P17 ship under construction at MDL

- ✓ First design to allow helicopter operations in sea states upto 6.
- ✓ First design to incorporate CODOG propulsion, (Combined Diesel or Gas turbine)
- ✓ Optimized hull & propeller design to allow exceptionally high cavitation inception speeds.
- ✓ Increased automation & reliability through Integrated Machinery Control System, (IMCS).
- ✓ Enhanced 'survivability' under damage by 'zoning' of weapon, power & ventilation systems.

Preparations for the launch of Project 17 ship 'Satpura'

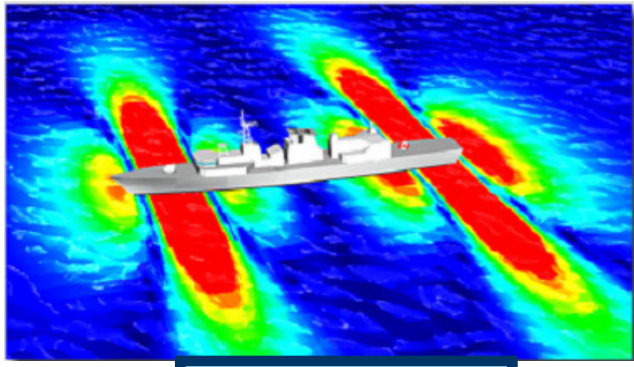
by the demands of the stealth features of the above-water hull form and superstructure. This on the whole has given it a gentle, more pleasing look of a modern warship.

Stealth Technology **:** Implementation of stealth specification for P-17 ships was an onerous task requiring development of noise isolation equipment (rafts/ enclosures), interaction with the equipment supplier to ensure that their equipment meet the stipulated specification, development of RCS materials and host of other activities, in which a number of DRDO laboratories were also involved who gained immensely from this experience. NSTL Visakhapatnam, for instance, has developed a number of stealth products for reduction of Acoustics, RCS & IR signatures of ships that have been accepted for induction on P-17 and new design ships.

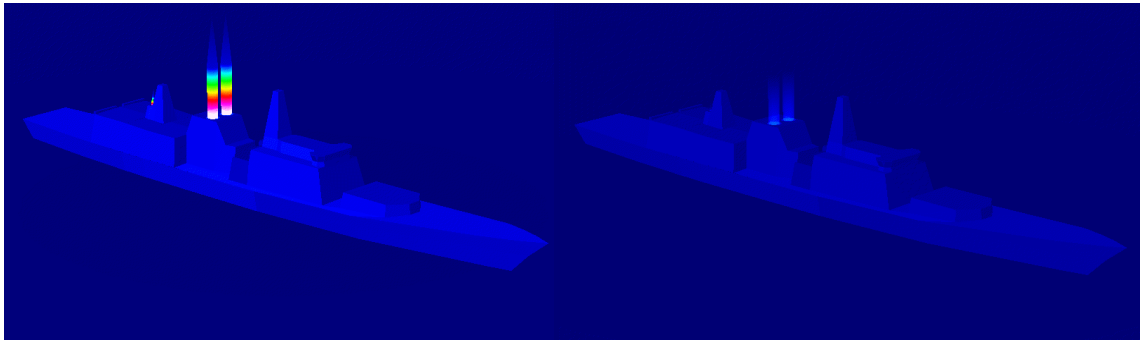
- ✓ ACOUSTICS : G.T. intake silencer, Acoustic Hood, Enclosures, Silencers for ventilation fans and constrained layer damping foundations were developed and underwent shipboard evaluation. Appreciable noise signature reduction was achieved.
- ✓ RCS : Using Radar Transparent Materials, developed Stanchions and Weapon enclosures for RCS signature reduction.

STEALTH

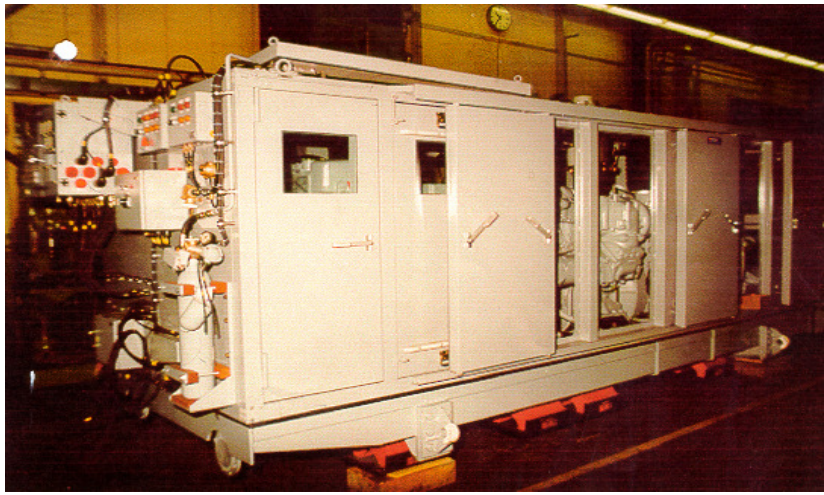
Model of a Indian Navy's latest stealth ship, showing the design features like special hull form, minimal use of exposed fittings, etc., that lead to reduction in the radar cross section.



ELFE SIGNATURE

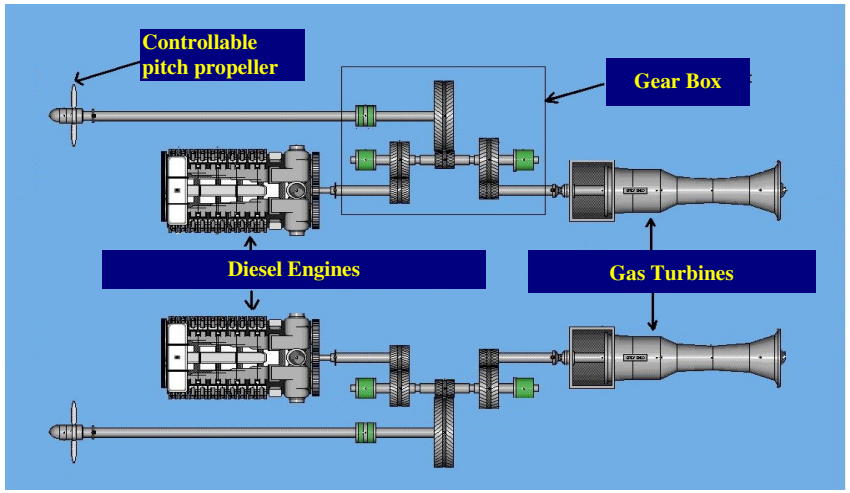


INFRA RED SUPPRESSION

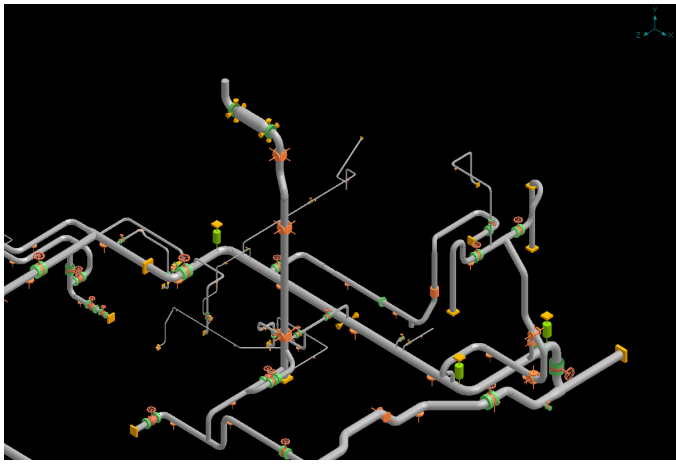


DA ON DOUBLE RESILIENT MOUNTS INSIDE ACOUSTIC ENCLOSURE

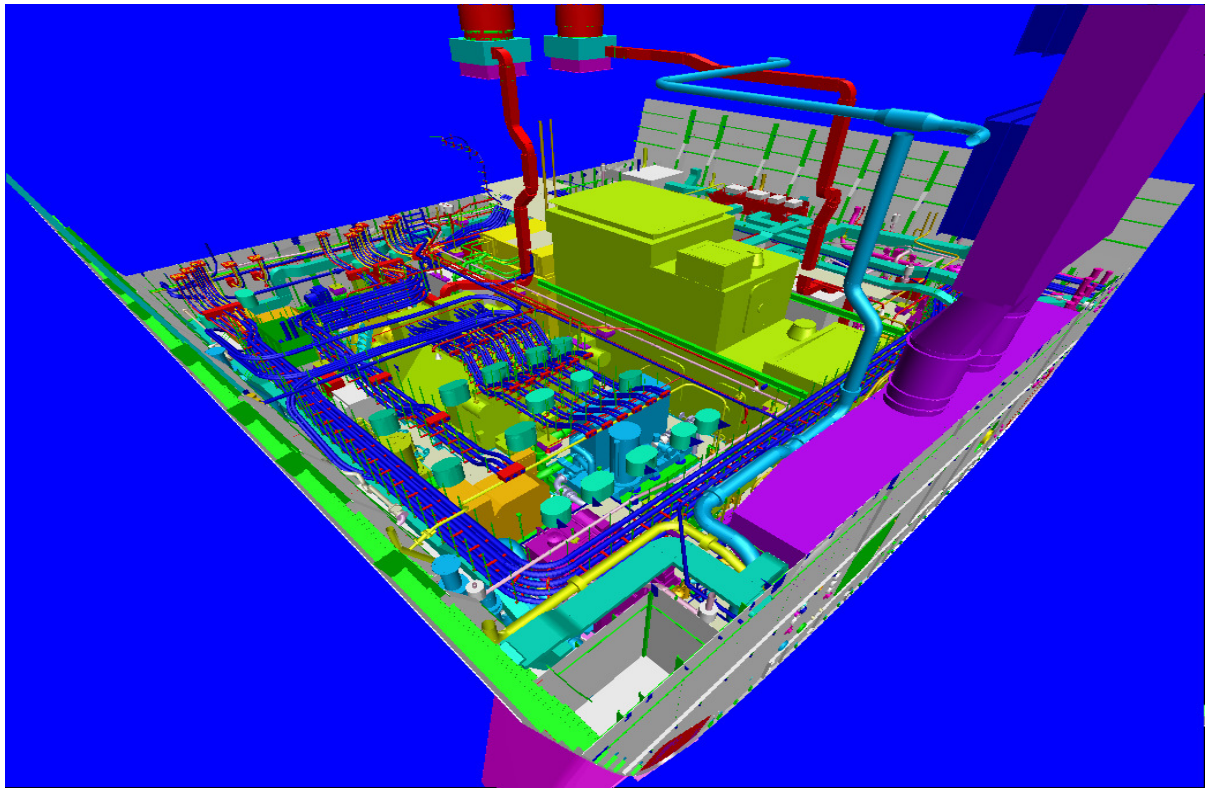
Typical output from DGND's "Specialist Design Groups" : PSI and HVAC



Typical CODOG(Combination of diesel and gas turbine) propulsion system on modern Indian warships



Typical 3D model of piping system



An isometric 3D model of Engine Room of indigenously designed warship

- ✓ IR : D/E IRSS device has been developed and factory acceptance trails completed and achieved excellent IR reduction. GT IRSS device has been developed and tested at GT test bed. Excellent IR signature reduction was achieved.

- ✓ In addition to the above products, NSTL is also working in the areas of prediction of IR, Acoustics, Radar & Magnetic signatures; & the Infrastructure facilities, for measurement of these signatures.

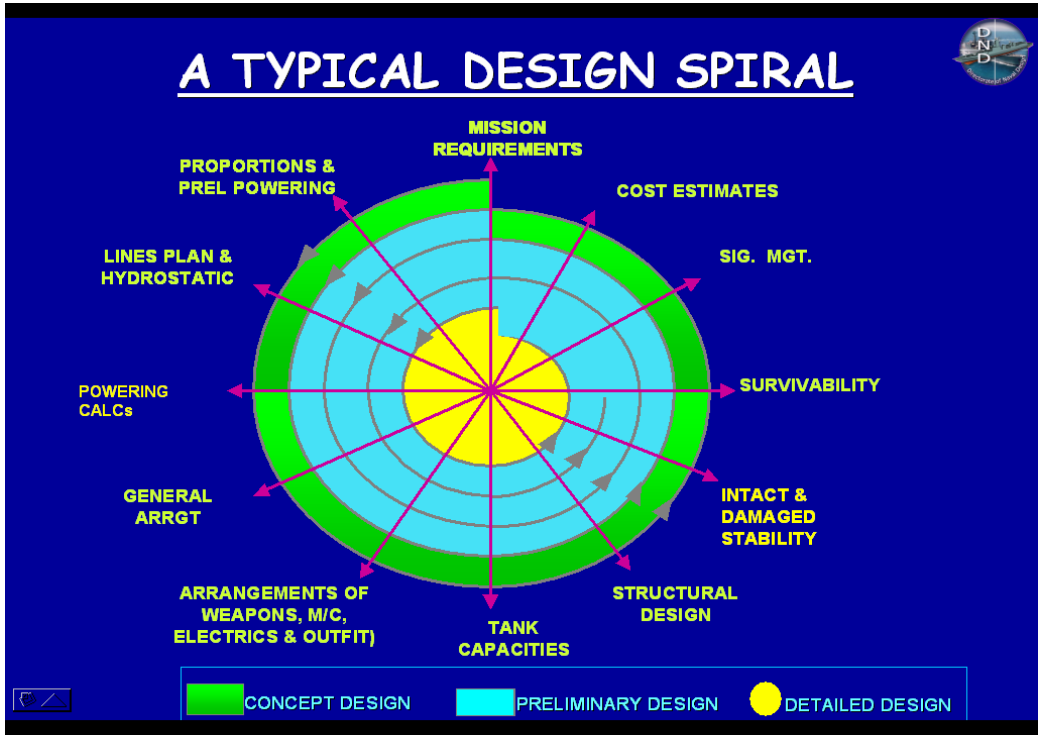
Follow-on Destroyers **:** A series of three ships, under Project 15-A, conceived as follow-on of the highly successful *Delhi* class destroyers, is currently under construction at MDL. The first of the class, launched on 30 March 2006, is named *Kolkata*. The production of the ship had commenced in March 2003 & it is slated for commissioning in May 2010.

P 15-A ships have the same main machinery as the earlier destroyers, with an updated weapon package, which has an even higher indigenous component; but they will 'look' different from the P 15 ships on account of stealth. They also have 'modular' living spaces. According to the DGND, "When *Kolkata* takes to the seas, she will stand tall amongst her contemporaries from the advanced Navies & emblazon the remarkable design & shipbuilding capabilities of India."

ASW Corvettes **:** Four nos. ASW Corvettes, designed under Project 28, are 'state-of-the-art' ships, updated to contemporary world standards in Structure, Stealth & Automation. They will carry a totally new/latest weapon package & sensors, mostly indigenous! The entire propulsion machinery & gearbox in these ships will be on a 'raft' foundation to minimize the noise signature. The Project is a collaborative venture between DGND & GRSE, who is carrying out the 'detailed design'. Construction of the first vessel has begun in Aug.'05 & the expected build period is 24 months.

INS Kolkata entering water at MDL

Specialist Design Groups **:** Having 'mastered' designing the conventional hull forms, it is natural that DGND designers venture into the un-conventional. Ship design is undergoing a revolution with the fast paced development of multiple hull designs and fast vessels. Future ship design will be based on the users requirements with a total systems engineering approach to design, construction, test and evaluation, operation and ultimately disposal. Towards this end, a number of 'specialist groups' have been formed with-in the DND (SSG), who act as the 'custodians' of the up-to-date knowledge in their area of specialization & the 'consultants' to various design-groups. So far, following 'specialist' groups have been constituted :



- ***Structural Design Group*** : This group specializes in structural design, linear and non linear static and dynamic analyses, shock analyses and development of Naval Ship rules. The group also draws up comprehensive guide lines for shock consideration in detailed design of structures.

- ***Propulsion System-integration Group*** : This group compiles all the propulsion requirements for a new design and makes performance estimates. It liaises with external consultants for propulsion system integration of new designs.

- ***HVAC Systems Group*** : The heating, Ventilation and Air conditioning group is responsible for drawing up the design philosophy for this important system in new design ships. It carries out preliminary system design and helps the shipyard for drawing up detailed scope of work and specifications for ordering the system. The group gives special emphasis to gastight integrity and citadel requirements of the new designs.

- ***Stealth Group*** that has the expertise in :

  - RCS Signature Management, which includes: Design of exposed structures to reduce RCS, Development of add-on suppression measures like Screens, Radar absorbent/ transparent materials, etc. in collaboration with the laboratories like N

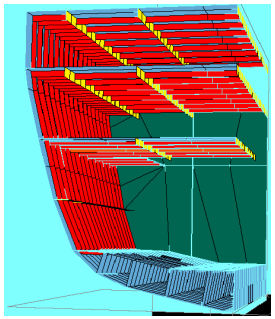
A modern Indian warship in action

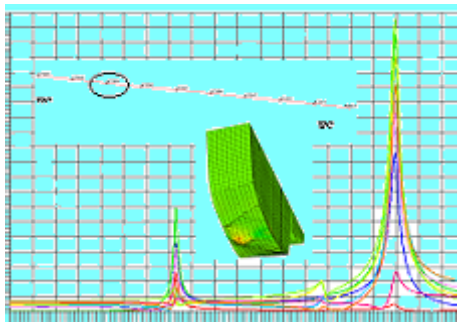
ture Management, i.e. Prediction of IR signatures & evaluation of possible 'suppression' options, e.g. Exhaust-duct metal cooling, Exhaust plume cooling, etc.

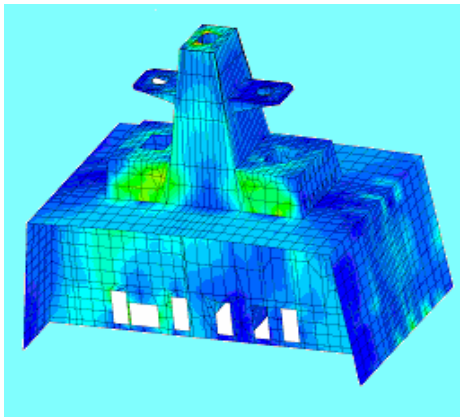
- Noise Signature Management, which includes Monitoring the noise & vibration levels of individual equipment; Estimation of radiated under-water noise & self noise; Evaluation of noise-reduction options, viz. Shock & Vibration mounts & rafts etc. &

- ELFE Signature Management, i.e. Analysis of ship's electrical field due to electro-chemical processes like corrosion, (between the hull, propeller & shaft, & sea); recommending Active shaft grounding, ICCP systems with low ripple content, etc. This important specialization is presently in the process of development.

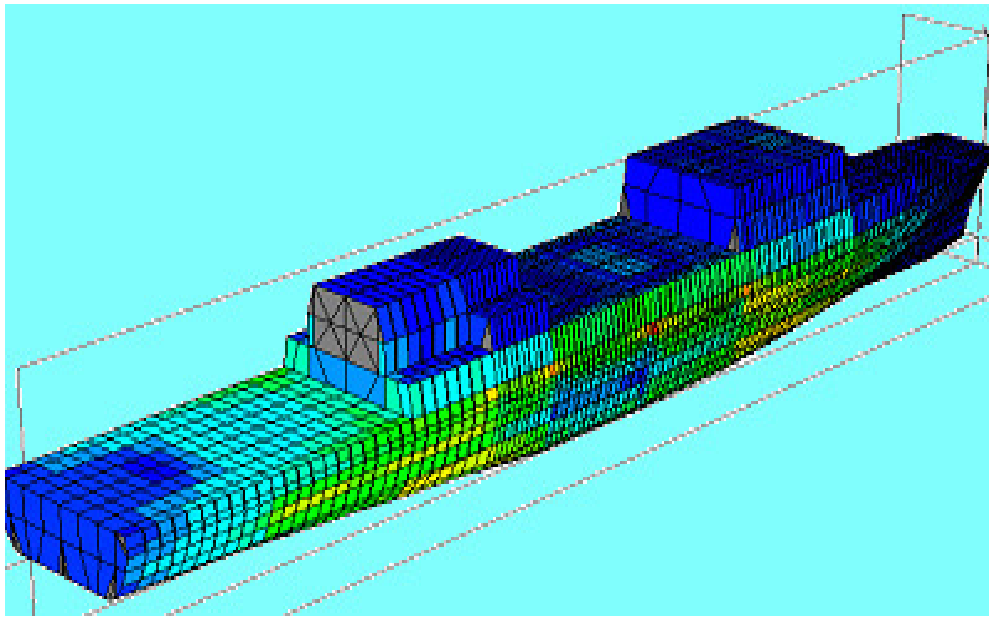
FINITE ELEMENT ANALYSIS FOR STRUCTURAL INTEGRITY

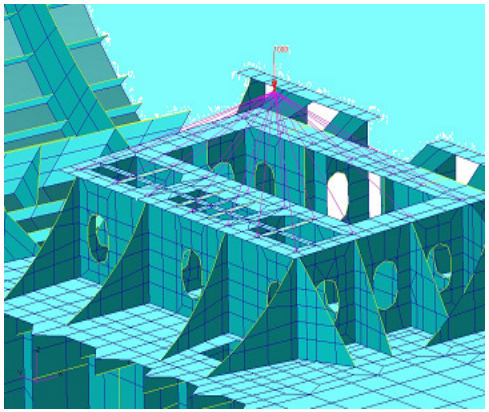


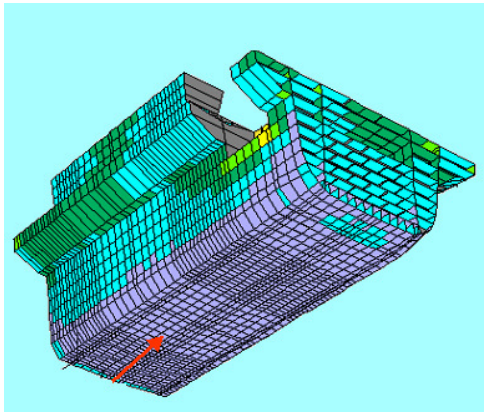


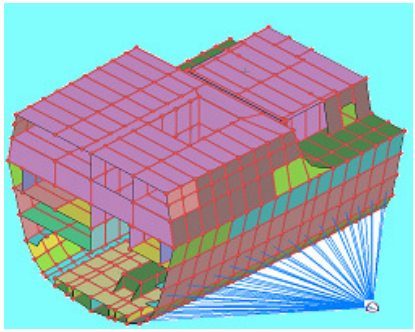


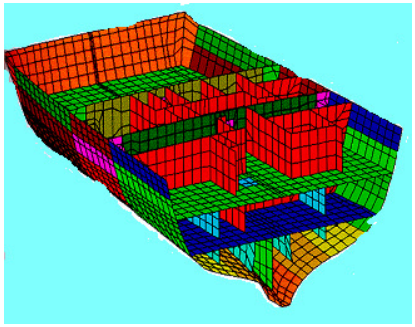
Proof of the pudding…











… is in the `eating' !

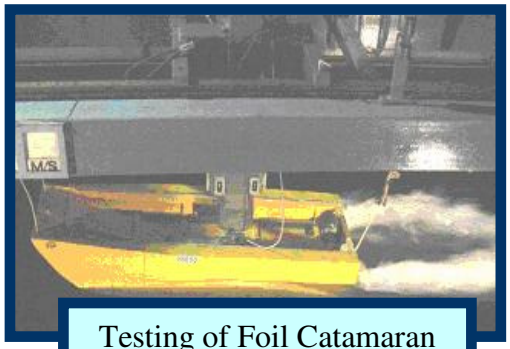
Hydrodynamic Model Testing of indigenously designed warships

Cdr NP Gupta explaining the model testing of P15 ship, to the CNS at SSPA

Testing of Submerged Body Model using Vertical Planar Motion Mechanism

Cdr KN Vaidyanathan overseeing the model test of P17 at MARIN, Netherlands

P17 Model Test at MARIN



Testing of Foil Catamaran in HSTT at NSTL, Visakhapatnam

Manoeuvring Tests in a Seakeeping & Manoeuvring Basin at NSTL, Visakhapatnam

Generation of Waves using Segmented Wave Maker at NSTL, Visakhapatnam

Other Initiatives **:** Conceptually, the modern warship is a package of sophisticated equipment, carried on a platform that seldom gives the impression of being very hi-tech. And the equipment does play a decisive role in a war. So the platform tends to get neglected – notwithstanding the fact that the platform has & does enjoy an independent existence without the equipment; the equipment however, have no locus-standii without the platform! It is again the usual "Actors & the Director" scenario. The loss of a warship in peacetime is a clear indication that the platform had been taken for granted.

Loss of INS Andaman in August 1990, brought back the memories of *HMS Captain* episode & a re-discovery of the importance of Constructors. In addition to the Fleet Constructor Officer (*FConO*), the organizations of the Command Constructor Officer (*CconO*), & the Hull Inspection & Trials Unit (*HITU*), got due recognition. Today, the *FConO is the right-hand man of the Fleet Commander in respect of all the 'hull'* related issues of ships. *FConOs* have helped ship-staff to improve habitability conditions onboard ships and submarines, directly affecting morale of the crew.

CConO interfaces with NHQ, Command, Fleet, Dockyard, Ships and Submarines in respect of all hull related activities. Till end of 1990s Navy was operating more than hundred types of boats causing serious problems in respect of inventory management. *CConOs* have helped the Navy to reduce the number of boats to about ten types covering all operational scenarios. Trials in respect of indigenous industry like ultrasonic steel thickness measurement without removal of the protective coating, was initiated and subsequently validated by participation of *CConOs'* organizations.

Braving the waves - INS Ganga

Similarly, *HITU* has become an institution for regular maintenance of hull, watertight boundaries, gas tight boundaries and hull equipment. It has systemized Structural Health Monitoring System for the ship structure ensuring alertness of Ship-Staff. *HITU* team moves into ships and guides the Ship-Staff in undertaking correct maintenance of

doors hatches, equipment, with an aim to improve battle worthiness of the ships. *HITU* is empowered by Navy to take stock of the hull status of operational ships as well as submarine.

The other important initiative taken in this direction is the introduction of 'sea training' for Constructor officers. This will have many advantages :

- ✓ It will definitely add to the professional knowledge of the Constructor officers.
- ✓ The lacuna that Constructors design ships without having the first hand experience of life at sea, on board ships, will be taken care-of.
- ✓ The post-retirement career prospects of Constructor officers will get a little better.

Senior Constructor officers attending a training session

The Next Decade

The story of Naval Constructors over the five decades since the formation of the Corps, has been that of success… From *Conception* to *Consolidation, Transition, Evolution*, & *Recognition*… And it has been a hard-earned success! It was possible, despite the people being 'low' in *quantity*; because they were 'high' in *quality*. While the earlier generations displayed great leadership & initiative, the younger generations were equally quick in grasping & getting on! This is precisely what they had been singing along for the last twenty years, as the bottom-line of their 'corps song'… "The coming generations *have* the potential…"

The 'budding' Constructors, while under-training as 10+2 (Technical) entry Cadets, in the Dept of Ship Technology (DST), at Cochin University of Science & Technology (CUSAT), have invariably been out-performing all other students, in all the extra curricular activities. In the inter-university annual cultural festival, 'Talentime', the various batches (as part of the DST) have been overall winners 8 times out of the last 15 years. The intra-University Arts festival has also been consistently won by the DST team throughout these years. In the intra-University CUSAT Sports Championships too there has been a complete domination over other colleges, with the DST team winning the Championships 13 times in the last 15 years.

Family outing of NC Officers with Prof . Mitra,, ex – HOD, Deptt of Naval Arch & Marine Engineering, IIT, Kharagpur, and Mrs Mitra.

The CUSAT scheme of 10+2 Tech entry commenced in 1987 however it was only the next year that Cdr. VV Rao was appointed as full time faculty, in accordance with the MOU signed between CUSAT & the Indian Navy. With the twentieth course in its cradle now, the Naval Construction Wing at CUSAT boasts of an excellent alumni of

over a hundred Constructors!

Some of the major achievements of individual Constructor officers, while U/T at CUSAT, are worth the mention :

- ✓ Cdr A Chattopadhyay, Cdr M Batra, Cdr S Sengupta, Cdr R Sreedharan, Cdr V Maniar & Cdr B Deepak represented CUSAT in University Championships in various sports during 1988-92.

- ✓ The title of 'Best Athlete' in the annual CUSAT Sports Championships has been won by Lt Cdr CR Rejith (1994 to 1996), Lt Cdr S Ashok (1997), Lt D Sunil Kumar (2002, 2003) and SLt Mohd Irfan Khan (2003 to 2006).

- ✓ Cdr M Bhuraria, Lt Cdr Amit Ray and Lt Rahul Chandel have won the award for 'Best Individual Performance' in the annual University Arts Festivals (1992, 1997 and 2004, respectively).

- ✓ Lt Cdr CR Rejith, Lt D Sebastian and Lt Rahul Chandel won the coveted title of 'Shogun' in the best personality competition in the inter-University cultural festival 'Talentime'.

- ✓ Cdr A Chattopadhyay and Cdr M Batra represented SNC in Badminton in 1988.

Cricketing Constructors at NCW, IIT, Delhi

- ✓ Lt RV Nair was selected for the Southern Naval Command Cricket team in Navy Championships in 2000.

- ✓ Lt A Pandey, Lt Aadil Mohideen and Lt Rajesh P represented SNC for Basketball Championships.

Five batches, (NEC 15 to 19), of budding Constructors,at NCW, Cochin University of Science & Technology,

The “Budding Constructors” , pitching a tent at Munnar

- ✓ Cdr Subir Sengupta was the University Cultural Secretary and Lt Aadil Mohideen was the University Sports Secretary in CUSAT.

- ✓ SLt. M Irfan Khan was awarded the C-in-C commendation as a Cadet for outstanding performance in sports at command level.

The undertrainee NC officers have had a history of active participation in sports and cultural activities at IIT Delhi also. There were separate hostels for post-graduate students in the early years of the NCW course. The presence of naval officers in Shivalik hostel propelled it to the top in all extra-curricular activities and it won the IIT championships for 'Best Hostel' in 1986, beating all the other Undergraduate hostels.

- ✓ In the year 1985, Cdr I Sivadasan, Cdr Jacob Isaac, Cdr G Pradeep, Cdr SK Bharadwaj and Cdr KS Raj represented IIT Delhi in Athletics, Basketball, Weightlifting, Cricket and Tennis respectively. Cdr Jacob Isaac was awarded the 'Blazer' for the 'Best Sportsman' of IIT Delhi in 1985.

- ✓ In later years also, Capt Saibal Sen (Football; 1986), LtCdr NT Anil Das (Athletics; 1986), Cdr G Harish (Basketball; 1993), Lt Cdr CR Rejith (Athletics; 1997, 1998) and Lt Bhagyashri Sawant (Basketball; 2003) represented IIT Delhi at Inter-IIT Sports meets.

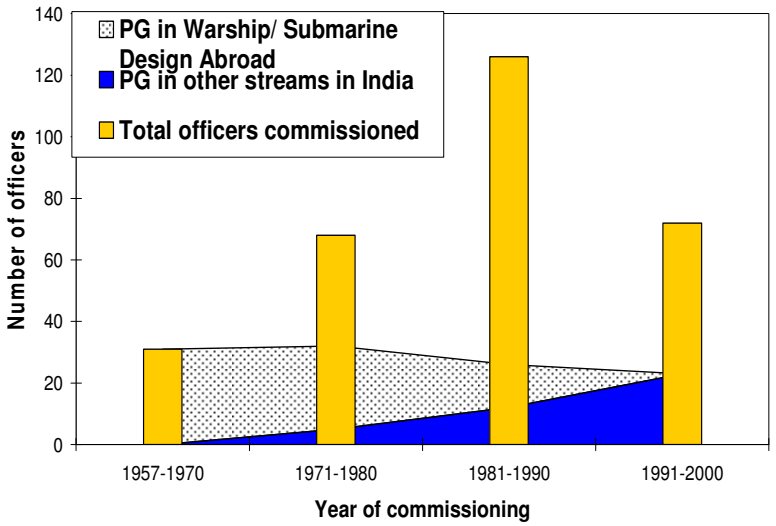
- ✓ Lt Cdr B Tyagi was elected as the General Secretary for the Board of Hostel Management in 1998.

- ✓ Lt Karthik Das and Lt D Sunil Kumar were active members of the IIT Delhi Choreography team and won prizes in 'Rendezvous' and other inter-University competitions during 2004 and 2005.

In the camp…

- ✓ Lt. Bhagyashri Sawant was the first lady officer to join the Corps in 2001, along with Lt. Smitha Mohanta & Lt.Manju Kumari. Three more lady-officers have since joined the Corps; Lt. Richa Verma in 2002, Lt. Ragini Singh in 2003 & Lt. Sunala E. Augustine in 2004.

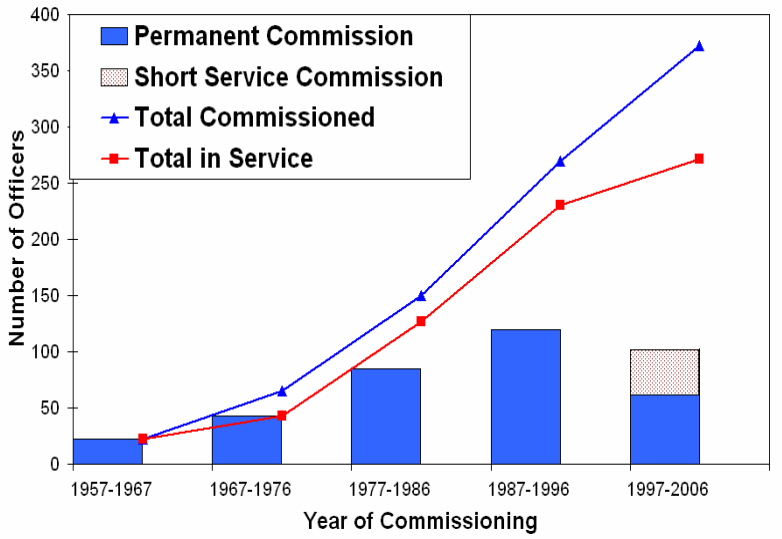
The in-house training facilities in the form of CTO & the two NCW's have grown from strength to strength over the years. However, to be effective Constructors, there continues to be the need that these talented 'next generation' officers are provided with requisite opportunities to improve upon their *professional quality*, through higher-level courses in warship design & construction. The 'elder generation' officers had all undergone PG courses at UK & USSR. These are now totally missing! Instead, few officers indeed get opportunity to do PG courses in varied technical disciplines… which is good, because it does give them an 'exposure', unfortunately it can not be a 'substitute' to a very 'disturbing' loss!



The other disturbing trend revealed by the data is the alarming *rate* at which the young Constructor officers are resigning from the commissioned Service. This is a clear indication that there is something '*wrong*'. It was 'bad' enough to resort to "Short Service Commission", which perhaps became inevitable to make up for the grave deficiencies in the last decade. It is far worse to loose trained officers than to live with lesser numbers!

The situation is going to worsen further in the coming years, as the requirement of Naval Architects in commercial shipbuilding is at an all time high at the moment, & will remain so in the near future!

The coming decade therefore, should be a period of '***Reflection***'!



Conclusion **:** Today, over 2/3rd of the Indian Navy's frontline surface Warships fleet comprises ships designed by the DND (SSG). The driving factors for war-ship design & construction will continue to be the 'capability' requirements of the Navy, the technologies available in the country to meet those requirements, and the costs associated with developing and incorporating these technologies. The *capability requirements* cover areas such as the 'threat perception', military lift capacity, loading and unloading needs, range, endurance and replenishment needs, etc; the *new technologies* determine how these capabilities are achieved. These technologies define areas such as construction methods, propulsion systems, construction materials, signature management, survivability, self-protection, command and control and among other aspects, the legal obligations associated with operating ships on blue water or in port, (e.g. pollution control… not only controlling the exhaust gas emissions, but also the sewerage, garbage, and oil discharges; i.e. lowering of allowable pollutant levels due to increasingly restrictive environmental laws and requirements. Meeting exhaust gas emission requirements, for instance, could have a considerable effect on the types of fuel and therefore the types of propulsion system that could be used), & so on.

An effort has been made in this book to systematically present the history of Naval Architecture in India, & that of the Corps of Naval Constructors in Indian Navy; the largest single 'body' of practicing Naval Architects in India, designing & building warships. It is brought out that so far this 'body' has been quick to absorb the 'new technologies'. The success story of the Corps in the short span of fifty years is the sure sign that 'ship-design/building' continues to be in the 'Indian blood'… & that, a hundred year 'squeeze' by the Britishers, was not able to 'erase' it al-together. It just needed favourable environment & the right people, to spring back to life. And it will no doubt continue to 'grow', as long as the environment remains favourable & the people, 'right'!

The bottom-line is that the people are 'right', right now… & as long as the people *are* 'right', all that is required for Naval Construction in India to grow, is, the favourable environment!!

Up, up & up… Naval Construction in India ?

LIST OF INDIGENOUSLY DESIGNED AND BUILT WASHIPS IN INDIA

Sl	Type/Class of Ship	Built (Nos)	Ordered/ Under Construction (Nos)	Total (Nos)
1.	Tugs	Many	-	Many
2.	SDBs	20	-	20
3.	LCUs	4	-	4
4.	Ocean Going Tug – Matanga, Gaj	2	-	2
5.	Survey Vessel – Sandhayak Class	8	-	8
6.	Cadet Training Ship – Tir	1	-	1
7.	P-16 Frigate – Godavari Class	3	-	3
8.	LST(L) – Magar Class	2	3	5
9.	P-25 Corvette – Khukri Class	4	-	4
10.	P-15 Destroyer – Delhi Class	3	-	3

11.	P-16A Frigate – Brahmaputra Class	3	-	3
12.	P-25A Corvette – Kora Class	4	-	4
13.	P-17 Frigate – Shivalik Class	-	3	3
14.	P-15A Destroyer – Kolkota Class	-	3	3
15.	P-28 ASW Corvette	-	4	4
16	P-71 Indigenous Aircraft Carrier	-	1	1
		54+	**14**	**68+**